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President's Page

Manpower and Education in Geophysics

Developments over the past few years have focused national attention on the need for a greatly expanded program of research in the broad area encompassed by geophysics. This, in turn, has very properly directed attention to the associated problems of manpower and education in geophysics. With the current healthy emphasis on coherent long-range planning of research programs, the matter of attracting adequate numbers of young people into geophysics and providing imaginatively conceived, soundly organized, and challenging programs of instruction that will insure skilled technicians, competent professionals, and creative scientists is rapidly taking on increasing importance and urgency. This is not a problem which is solely the concern of the colleges and universities, although their interest and their role are the vital elements. It is a problem which will require concerted action on the part of the colleges and universities, the scientific community generally and Earth scientists particularly, the federal and state governments—and certainly the American Geophysical Union. This may be one of the most important problems facing the Union during the next triennium.

With respect to additional manpower, a few guideposts have already been marked out. The Committee on Atmospheric Sciences of the National Academy of Sciences commented in 1958 that "the output of meteorologists from the universities is inadequate to meet even the static needs of the science" and proposed vigorous measures to increase interest in the atmospheric sciences and broaden courses of instruction. In 1959, the Academy's Committee on Oceanography reported that "The research programs envisaged ... will require an approximate doubling of the number of professional oceanographers at the doctoral level and an increase of rather greater magnitude in personnel of lower categories over the next several years. Obviously this necessitates doubling the educational programs as rapidly as possible." More recently, the *ad hoc* Panel on Hydrology of the Federal Council on Science and Technology stated that ". . . even a modest increase in research expenditures, let alone a possible 25 to 50 fold increase, would find the field of scientific hydrology totally unequipped to supply even a fraction of the demand for truly competent hydrologists" and said further that "it is a curious fact that in the face of this enormous expenditure for water resources [estimated by the Select Committee on National Water Resources of the United States Senate] there is no single institution in the United States whose primary interest is in the training of water scientists, hydrologists." Expanding programs in seismic research and the veritable explosion in space and planetary research with strong geophysical overtones are additional examples that could be cited—if, indeed, more are needed—to illustrate the magnitude of the demands for scientific manpower which will confront the geophysical sciences during the nineteen sixties.

It is useful to set the estimates given above against the quantitative goals set up by Dr. Richard H. Bolt in a recent NSF report, *Investing in Scientific Progress.* These call for an increase in professional scientists and engineers from the present number of 1.4 million to 2.5 million by 1970, with a doubling in the number of science and engineering doctorates. These increases, in turn, will require augmentation in the number of professional scientists and engineers teaching full-time in colleges and universities by something like 75,000, accompanied by a growth in annual expenditures for scientific and engineering education from the present $2.1 billion to $5.5 billion and a trebling in annual expenditures for basic research. Nor is the whole story told by these numbers. Within the past year the President's Science Advisory Committee forthrightly said, "We urge the importance for the country of an increase in the number of universities in which first-rate research and graduate teaching go forward together. The growth of science requires more places with superior faculties and outstanding students . . . we must hope that where there were only a handful of generally first-rate academic centers of science a generation ago and may be as many as fifteen or twenty today, there will be thirty or forty in another fifteen years." It is not unlikely that the desired rate of expansion in geophysics will exceed that which is held to be necessary for science and engineering in general. If this is so—and more precise estimates are certainly in order—the magnitude of the task that lies ahead of us begins to be clear.

But much more is required than merely providing scientists and professionals in the numbers that will be required. It is probably not too much to say that the character of the educational experience and the organization of the mechanism by which teaching and research in geophysics are conducted within the university are of even greater importance. The fundamental unity of the geophysical sciences and a proper balance of science and technology are beginning to emerge from the advances made during the past decade, and it is time that this began to be reflected more faithfully in the organization of academic and research activities within the universities. It is heartening to see that this has been recognized. For example, in its statement on *Education for the Age of Science*, the President's Science Advisory Committee commented, "The improvement of existing graduate departments in all fields of science and engineering is of great importance, but alone will not suffice. New areas have developed which, if they are to be explored, must draw talent and knowledge from several disciplines. Chemical biology and biophysics, geophysics and geochemistry, materials and information theory are examples of areas in which scholars from different disciplines should be encouraged to pursue joint interests. The urgency of such efforts must be recognized and flexible patterns of organization—and, certainly, new supplies of capital—will be needed. Students should be actively encouraged to pursue interdisciplinary interests." It is heartening, too, to see that this is beginning to take place at some of our great universities, and more thinking is being devoted to breaking down the hobbling departmental barriers which impede progress toward a broad-based, unified, analytical approach to the study of the Earth, atmosphere, oceans, other planets, and the interplanetary environment. New patterns of organization are beginning to emerge within the universities in response to the growing emphasis on the derived sciences. But the task has barely been started and much yet remains to be done.

The need for a re-examination of academic patterns is not restricted to the universities. There is yeasting and ferment, too, in the secondary schools. Even as teaching of the basic sciences at the secondary levels is undergoing extensive renovation, there is a growing realization that the Earth sciences provide an excellent vehicle for stimulating interest in science among potential scientists and in providing needed cultural background among those interested in a terminal education at the secondary school level. The success of experimental efforts in New York and Pennsylvania augurs well for an expansion of this activity into other states. But just as the renaissance in the teaching of physics, chemistry, and mathematics in high schools required the active collaboration of mature and knowledgeable scientists, so it is likely that some of the best minds in geophysics must be brought to bear on this problem. It would be a pity to permit keen young minds to be exposed only to the older type of geophysics when there is so much to be gained and so much excitement in the 'new' geophysics. We cannot dismiss our responsibility here by saying that the only real training in geophysics begins at the graduate level. Unless all the signs are misleading, the study of the environmental sciences is going to expand at the secondary school level whether we will it or not. Moreover, it is from the secondary schools of today that we expect to obtain the kind of geophysicists capable of coping with the problems of tomorrow.

The time would appear to be ripe for a thoughtful review of the problems touched upon above.

THOMAS F. MALONE

The Indian Ocean Expedition—An International Venture

ROBERT G. SNIDER

Coordinator, International Indian Ocean Expedition
30 East 40th St., New York 16, New York

The growing interest in 'inner space'—or in more conventional terms, oceanography—is readily indicated by the rapid development of the International Indian Ocean Expedition program. The program was conceived in 1957; in late 1959 it was agreed that SCOR (the Special Committee on Oceanic Research of the International Council of Scientific Unions) would sponsor the enterprise. In the ensuing two years it has taken form.

Over the next three years a fleet of ships from many nations—ships carrying highly specialized equipment and scientists—will be sailing in the Indian Ocean on new voyages of discovery. One of the last unknown areas of the globe will be under intensive exploration as the International Indian Ocean Expedition gets under way. Eight vessels from five different nations have already completed a dozen cruises. More than twenty countries, contributing more than forty vessels staffed with scientific parties will carry out more than sixty cruises varying in length from one to twelve months. Australia, East Africa, France, Germany, India, Indonesia, Japan, Pakistan, Portugal, South Africa, United Kingdom, USA, and USSR will provide from one to ten ships each. In addition, each country bordering the Indian Ocean will provide shore stations and personnel for local observations, particularly on tidal changes and meteorology. Denmark, Israel, Nationalist China and possibly some others will send scientific parties.

The Expedition, being carried out between 1960 and 1964, is the first large scale effort to obtain complete scientific information about the Indian Ocean. No ocean has yet received so much coordinated attention. In 1960 and 1961 intensive effort has been devoted at national and international levels to the development of integrated programs in four different disciplines to be carried out over an area equal to about half of the total land mass of the Earth. The Expedition is able to draw upon the experience obtained during the International Geophysical Year, to build upon the knowledge gained during that period and in addition, to utilize some of the institutions developed.

Scope of the Program—The Indian Ocean covers one-seventh of the surface of the Earth. In the countries bordering on it live 25% of the world's population. Although this vast area is less known and less understood than any other ocean, there is sufficient fragmentary evidence to indicate that biologically it may be the most productive of all oceans.

The international plan calls for a study of the entire system from below the bottom of the sea, through the water itself, with its biological contents and its physical and chemical characteristics, through the boundary between the sea and the atmosphere and on upward to the upper atmosphere. Investigations will be carried out in marine geology, geophysics and bathymetry; in physical and chemical oceanography; in biological oceanography and marine biology; and in marine meteorology and large scale atmospheric circulation.

Late in 1960 UNESCO agreed to co-sponsor the Expedition with SCOR. Besides the basic science involved, one major objective is the development of an oceanographic science and associated institutions in the Indian Ocean area. The Expedition offers an opportunity to give training in marine sciences to nationals of the surrounding countries in their own area under the guidance of experienced scientists from outside.

Status and planning—The preliminary phase of the Expedition has been completed. Vessels from Australia, France, South Africa, USA and USSR have carried out exploratory cruises. In particular, *Vema* and *Argo* from the United States, and *Vitjaz* from USSR have covered large areas. The balance of 1961 will be devoted largely to consolidation of information and detailed planning. Several countries around the Indian Ocean will be making cruises in the course of their normal operations but only HMS *Owen* of the Admiralty Hydrographic Office is scheduled to operate this year from outside the Indian Ocean. Although ship operations for the Expedition are scheduled to continue through 1964, no detailed plans have been laid out for the last year. However, beginning in mid-1962 and continuing on through 1963 there will be an intensive effort by virtually all the participating nations using a number of ships, buoys, island and shore installations for tidal and meteorological measurements, submarines, airplanes, and satellites. On the basis of the accruing information, the detailed schedule for 1964 will be developed.

To draw up the preliminary international plan for the Expedition, SCOR appointed early in 1960 an International Indian Ocean Working Group of twenty-eight members under the chairmanship of G. E. R. Deacon, Director of the National Institute of Oceanography in the UK with V. G. Kort of the USSR as Vice Chairman. The group represented most of the prospective participating countries, with four members from the Indian Ocean area. Members of these groups have corresponded extensively. A minimum international plan was developed at a meeting in Copenhagen in July 1960. Sub-Working Groups in the fields of geology, geophysics and bathymetry; physical and chemical oceanography; and biological oceanography met to outline the scientific objectives of the Expedition, to define the problems to be investigated, to agree upon procedures to be used and standards to be maintained in order to get reasonably uniform and comparable results. More recently, between November 1960 and the end of July 1961, substantial attention has been given to a meteorological program for the Expedition. An international program suggested by a USA meteorological working group has served as background for more detailed planning by all participants. A SCOR meteorological Working Group, with representatives from most Indian Ocean nations and territories as well as from most other major participants, met in July 1961 in Bombay, India. Detailed plans for an observational network to study large scale circulation in the area, as well as for the establishment of a meteorological analysis and training center in Bombay, were developed by this group.

Within the basic framework of the internationally agreed upon minimum programs and the USA meteorological proposal, National Committees for Oceanic Research in the major participating countries have drawn up detailed national plans. Fourteen nations have set up working groups in each scientific discipline. The resulting programs, usually designed by the actual Expedition participants, have served to crystalize thinking and budgeting in each nation, and to stimulate recruitment of scientists. These plans include ship schedules and ship tracks and identification of the scientific personnel to be involved, equipment requirements to carry out the program, descriptions of the scientific problems to be investigated and a detailing of various responsibilities including the interrelationship of the several nations' activities. Such plans are currently being circulated between countries.

In the United States five Working Groups were set up under the Indian Ocean Expedition Panel of the US Committee for SCOR, which is also the National Academy of Sciences' Committee on Oceanography. These Working Groups dealt with marine geology, geophysics, and bathymetry; biological oceanography; physical and chemical oceanography; meteorology; and data handling and analysis. Through personal contact and rapid exchange of preliminary documents the planning of detailed national efforts is being coordinated to minimize subsequent delays in fitting programs together between countries.

Several international meetings, including the Tenth Pacific Science Congress in Honolulu in late summer 1961, will enable many of the participating scientists to exchange information. Several International Working Groups plan special meetings including some in Honolulu in order to work out a complete intercalibration of methods and standardization of techniques. Support for these meetings comes from SCOR, from UNESCO, and from the individual nations. The Honolulu meeting will also offer an opportunity for direct comparison of field techniques among Australian, Japanese, Russian and US ships which are expected to be there.

Plans are also being laid for the establishment of logistic and analytical centers around the Indian Ocean area and for the provision of laboratory space at various institutions for local work with research material. A major center for biological research and classification, particularly taxonomic, is being planned at some point in India under the joint support of the Government of India and UNESCO with some assistance from other nations. Cochin, in southwestern India, is being given serious consideration. A part of each biological collection will be deposited here for analysis and classification, and ultimate use as an Indian Ocean reference collection. Centers will be set up around the Indian Ocean primarily for training technicians. Training facilities of existing centers will be increased and opportunity provided for advanced training of at least sixty scientists a year from the Indian Ocean area in institutions outside the area. Such training would be specially directed toward participation in the Expedition.

Scientific problems—How does the Indian Ocean differ from other oceans and of what significance is this? It has several unique features. Outstanding is the 180° reversal of the prevailing winds twice a year in its upper part at the onset of the Northeast Monsoon and the Southwest Monsoon. Equally unusual is the fact that this virtually unknown body of water is the sole major ocean which is open at only one end.

The monsoon wind reversal creates varying currents at different seasons of the year which in turn affect the entire oceanic circulation. One result is that on each of four coasts of the Indian Ocean there is at some time of the year a wind setting up currents which create upwelling along the coasts with a consequent increase in nutrient circulation. This situation, plus the occasional observations in mid-ocean areas of vast quantities of dead fish on the surface suggests that the Indian Ocean may be one of the most productive regions of all the oceans. The fact that the land-mass of Asia closes the northern end of the Indian Ocean results in an oceanic system which at its closed end is fed by the great rivers of the Middle East going into the Arabian Sea and those of India, East Pakistan, and Burma running into the upper part of the Bay of Bengal carrying fresh water and sediment. Cold water enters only from the Antarctic on the south.

The overall objective of the Expedition is to study the effect of these significant phenomena on the Earth, the sea and the atmosphere—the entire ecological system—and to understand their behavior.

Physical and chemical oceanography—Scientists will try to answer questions such as these. How long does it take the winds to set up a current? How rapidly does a current deepen with time? What proportion of the energy required to maintain an ocean current comes from wind? What proportion from horizontal density gradients due to regional climatic differences? How does internal friction and friction with the bottom influence the velocity-depth distribution? What is cause and what is effect in the general circulation of the oceans?

To answer these will require a wide variety of observations to be taken by each vessel. Almost every ship will cruise in each of the two monsoons. At intervals of ten to one hundred miles water samples for salinity and other characteristics and temperature measurements will be taken at various depths. Measurements of currents at the surface, and at various depths, will be recorded, together with their seasonal variations. Currents of the Indian Ocean are ill-defined and there is great interest in whether an equatorial counter-current exists similar to that found in the Pacific and the Atlantic at considerable depths. The major water masses will be defined and density layers described. The network of ship coverage already planned is reasonably satisfactory for the region north of 40° S. Extension of plans as the Expedition progresses can be expected to fill in gaps in the northern part and extend observations in the southern part through cooperation with the Antarctic investigations.

Chemical analysis of water samples will throw light on such questions as these. What is the distribution of plant nutrients and dissolved organic compounds in the various parts of the Indian Ocean? What is the effect of drainage water on sea water in a partly closed basin? How can one describe the circulation by C^{14} dating of water?

Water samples will be analyzed for oxygen, inorganic phosphorous, total phosphorus, silicate, nitrate, trace elements and $Carbon^{14}$.

Marine biology—All ships will carry out a minimum biological program of standard water sampling and collection of biological specimens by various types of nets and trawls. There is preliminary agreement on standardization of techniques for biological sampling and further discussions will be held. The overall objectives of the minimum program are threefold. First, study of the three-dimensional distribution of plants and animals in the Indian Ocean. Second, investigation of the quantitative ecology of the plankton. Third, collection of as much information as possible about the fisheries of the Indian Ocean.

Some vessels will make biological oceanography their primary mission during part or all of a cruise. In addition to the minimum program, they will concentrate on such biological phenomena as the coastal upwelling around the entire Indian Ocean; the study of equatorial divergences; the study of coral reefs and their surrounding environments; the problem of massive fish mortality; and the special problems surrounding regions of convergence.

The United States plans to equip one new vessel primarily for biological investigation. This ship would probably operate for about two years in the Expedition. At least one other US vessel will devote substantial time to biological research. The United Kingdom plans a program of biological studies in the southern part of the Indian Ocean. All the countries bordering it will emphasize biological investigations. In particular, Australia, East Africa, India, Pakistan, and South Africa will be specially concerned with biological work and India will place its major effort on problems of the continental shelf. Emphasis will also be placed on the study of benthic organisms, which will be closely associated with some of the geological work. A conservative US estimate suggests that some 300 biologists will be involved in the Expedition.

Marine geology, geophysics, and bathymetry—Topographic features and geology of other oceans have been studied with some detail in the last few years. Vast gaps in knowledge exist in the Indian Ocean and these have only just begun to be filled by the cruises of *Vema*, *Vitjaz* and *Argo*. A bathymetric chart of the Indian Ocean shows great distances between contour lines and a lack of detail which is characteristic of our knowledge of this area. Three general groups of problems require detailed investigation. First, what are the major crustal features of the bottom of the Indian Ocean? What are the characteristics of the trenches, of the mid-ocean ridges, of the rift zones, of the basins, and the continental margins? The arrangement of these components and their relationship to the structures of the bordering continents are markedly different in the Pacific and Atlantic. Is the Indian Ocean a Pacific or Atlantic type ocean?

A second area of exploration deals with sedimentary processes and records. What is the relationship between the geophysical and the sedimentary provinces? What is the significance of dolomite in the area? What are and have been the biological processes occurring which may be revealed by cores and by analysis of the marine sediments? What are the mineral resources in the Indian Ocean which might be tapped from bottom deposits?

A third set of problems relate to the boundary relations of the geological features in the Indian Ocean. We need a careful definition of the eastern margins, of the northern and western margins and a description of the general problems of boundaries within the various areas of the Indian Ocean. Furthermore, the islands within the Indian Ocean vary from coral to granite bases, with volcanic islands in the southern part. What will paleomagnetic records and other investigations show about the history of the Indian Ocean and the associated areas?

To obtain this information vessels in the Expedition will study bottom topography through the use of precise echo sounders having an accuracy of one part in five thousand. Some ships will examine the crustal structure of the bottom by making seismic tests. Such cruises will not follow rectangular coordinates but rather will follow the known or likely variations in the bottom structure in order to reveal those particular features which are unique to it rather than to a water mass or an air mass. Sampling of the bottom will be carried out by taking deep cores periodically, by dredging at frequent intervals, and by bottom photography. At critical points heat-flow measurement will be recorded and some ships will make magnetometric and gravimetric measurements.

Meteorology—Since atmospheric phenomena have much to do with the Indian Ocean's unique character, an understanding of the entire system of ocean and atmosphere requires study from the upper layer of the ocean up to the upper atmosphere. Meteorologists in conjunction with oceanographers are interested in answering such questions as these. How can the large-scale atmospheric circulation of the Indian Ocean region be described? How can evaporation and vertical heat flux be determined over large areas? What is the areal distribution of vertical flux of water vapor, heat and momentum? What are the local interface fluxes at the air-sea boundary? What is the average energy transfer, that is, the heat budget, for the atmosphere and the ocean? How do we interpret satellite cloud photographs and infra-red measurements in terms of such meteorological observations?

Using the preliminary US proposal as the basic working document, a SCOR meteorological working group met in Bombay in late July 1961. Most of the countries and colonies around and in the Indian Ocean were represented together with representatives from Japan, the United Kingdom, the United States, the United Nations Special Fund, the World Meteorological Organization and SCOR.

The establishment of an International Meteorological Center at Bombay for the Expedition was proposed. Its role would include collection, processing and analysis of meteorological data for research and operational purposes; advanced training of meteorologists from the region; and servicing and testing of Expedition instruments. It will be the focal point for the large scale circulation studies. A request for financial assistance from the UN Special Fund will be presented by India, together with endorsement by several Indian Ocean nations. Further support is anticipated from the United States.

Several recommendations were adopted concerning the study of the large scale atmospheric circulation of the Indian Ocean. Commitments were made by the several nations and colonies for participation in an observational network of upper atmosphere phenomena. Additional observation requirements were outlined. Some UK support and substantial US support for these is expected. Shipboard and island observations will be linked to coastal reports.

Training—The development of oceanography as a science integrated into the cultures of the Indian Ocean nations is an objective of the Expedition as important as obtaining fundamental scientific knowledge of an unknown area. To achieve this goal UNESCO, several nations and various intergovernmental agencies, and some private foundations will assist in advanced specialized training of Indian Ocean nationals for participation in the Expedition.

Facilities for training post-doctoral scientists in advanced shipboard research techniques will be available in the United States (at least fifty per year), in the United Kingdom (about nine per year) and in Japan (about seven per year), and possibly in other countries. These individuals will be trained to take senior positions in scientific parties in their own countries. In addition, general oceanographic training and technician training in various marine disciplines will be increased in the region, with the assistance of UNESCO to various national governments.

In addition, qualified scientists from the Indian Ocean region will ride ships of other nations during the Expedition, to obtain experience in their own waters in association with experts from other areas. In all, more than 500 scientists from all over the world will probably be involved in the Expedition from 1960 through 1964.

Data handling—To achieve maximum results during the brief life of the Expedition, rapid data processing and analysis is essential. For conventional oceanographic observations the IGY World Data Centers A and B (Oceanography) in USA and USSR will be used. The Moscow Center continues, and a new Oceanographic Data Center in Washington supported by five government agencies under US Navy Hydrographic Office administration will provide American facilities. Individual institutions and scientists will work up their own data and exchange it directly with others, as well as through centers. An effort is being made to provide current analyzed data for the design of subsequent cruises. Analysis of mean sea level will ordinarily be accomplished by existing agencies and institutions. Meteorological data bearing on large scale circulation problems as well as some other data will receive initial processing at the Bombay Center. Current analyses will be undertaken there. Individual participating institutions will undertake subsequent research on these data.

Without a new facility biological collection will overwhelm the traditional centers of taxonomic analysis, the museums and universities. To alleviate this problem plans are being developed to establish a Biological Center at a convenient point in India, operated by India with substantial assistance from UNESCO and from participating nations. Biological samples will be divided by the ships, which will send half of each sample to the center for basic classification and analysis. The collection would serve as an Indian Ocean reference source and after primary sorting, specialists in various biological fields will be brought in for final analysis.

United States participation—Major ship-operating institutions involved include Scripps Institution of Oceanography which will conduct some joint operations with the University of Rhode Island, Woods Hole Oceanographic Institution, Lamont Geological Observatory of Columbia University, the US Coast and Geodetic Survey, and the US Navy Hydrographic Office. The bulk of the financial support to private agencies will come from the National Science Foundation and the Office of Naval Research, with added help from the Bureau of Commercial Fisheries, US Geological Survey and others.

Major meteorological centers for the US Expedition effort will be the University of Hawaii, University of Washington, and the University of Michigan. The biological program is centered at the Woods Hole Oceanographic Institution. However, in this and the other disciplines, every effort is being made to stimulate the widest possible participation by interested and qualified scientists who wish to carry out oceanic research.

John A. Knauss, Dean of the School of Oceanography, University of Rhode Island, but currently at Scripps Institution of Oceanography, is the Chairman of the US Planning Group for the Expedition and also Chairman of the Working Group on Physical and Chemical Oceanography; Colin S. Ramage of the University of Hawaii is the Scientific Director of both the US and SCOR's International Meteorological Program; John H. Ryther of Woods Hole Oceanographic Institution is the Scientific Director of the US Biological Program; Robert L. Fisher of Scripps Institution of Oceanography is Chairman of the US Working Group on Geology and Geophysics; and O. E. Sette of the Bureau of Commercial Fisheries at Stanford, California, is Chairman of the US Working Group on Data Handling and Analysis. These five individuals constitute the planning group of actual participants who are responsible with their Working Group members, for the detailed design of the US program.

End results—The Expedition is the first full scale effort to coordinate oceanographic and meteorological observations in a single oceanic system. The findings will be published in part as papers by individual scientists in professional journals. These will be issued later as a collection of reprints. Furthermore, an atlas describing the Indian Ocean's characteristics will be published.

The international character of participation, and its consequent impact on all oceanography, is indicated by the current activity of the nations already involved.

Finally, the fundamental science developed during the Expedition in all phases of oceanography and meteorology will serve as a base for understanding of the processes of this vast oceanic system on which applied sciences can build for the direct benefit of the large population of the Indian Ocean area.

Round Table Discussion on Continental Haze

JAMES P. LODGE[1]

Chairman of Committee on Atmospheric Chemistry,
Section of Meteorology
U. S. Public Health Service, Cincinnati, Ohio

As a portion of the joint national meeting of the American Geophysical Union and the American Meteorological Society in Washington, D. C., April 17-21, 1961, a round table discussion was held on the subject of natural continental hazes. The participants were W. D. Crozier, New Mexico Institute of Mining and Technology, Socorro, New Mexico; C. E. Junge, Air Force Cambridge Research Center, Bedford, Massachusetts; J. P. Lodge, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio; R. A. McCormick, Weather Bureau Research Station, Cincinnati, Ohio; V. J. Schaefer, Atmospheric Science Research Center, State University of New York, Schenectady, New York; Sean Twomey, U. S. Weather Bureau, Washington; Helmut Weickmann, U. S. Army Signal Engineering Laboratory, Ft. Monmouth, New Jersey; F. W. Went, Missouri Botanical Gardens, St. Louis; and F. E. Volz, Blue Hill Observatory, Harvard University. Dr. Lodge acted as chairman, and also presented some findings by Alexander Goetz of the California Institute of Technology, who was unable to be present.

The group agreed that the continental blue haze is a very real phenomenon. The blue color is a function of the size distribution. It occurs when there is a rapid increase of particle concentration with decreasing particle size over the range from 0.05 to 1.0 microns radius. Such a distribution can arise from nearly any source that yields particles in this size range, given sufficient attrition of the larger sizes. However, this type of size distribution arises more commonly from condensation of the non-volatile products of gaseous reactions. On the other hand, gray or brown hazes are caused by a relative predominance of particles at the upper end of this size range. These colors are noted in urban pollution of recent origin, where insufficient time has elapsed to permit loss of the larger particles. Cloud droplets are efficient collectors for all particles, and may subsequently evaporate, leaving the environment enriched in the larger particle sizes. This process probably accounts for the dark gray hazes frequently found mixed with cloud layers, or at inversions. If natural hazes consist of particles formed by the condensation of organic vapors, it also probably explains the fact that a relatively small percentage of the total solids in precipitation is soluble in benzene, inasmuch as the cloud droplets originally nucleate, apparently, on much larger inorganic particles.

When blue haze particles are collected, many of them are found to be volatile at ambient or very slightly elevated temperatures. The idea that they are organic in nature is reinforced by the almost total absence of such particles, or, in fact, of any particles at all, over the Greenland icecap. Some measurements of atmospheric turbidity in the vicinity of heavy forests show that the maximum concentration of haze occurs around noon. This is contrary to what would be expected from simple considerations of the daily variation of ventilation, and suggests a photochemical origin for this haze.

The extent to which hazes at remote points may be due to natural sources, compared with urban pollution which may be brought in, has never been evaluated. It is known that terpenes at substantial concentrations in air will form a haze when irradiated with ultraviolet light in the laboratory. However, no experiments have been run to date, so far as is known, at atmospheric concentrations. These hazes should be strongly hydrophobic and should not nucleate water clouds at ordinary supersaturations.

Several experiments that would shed further light on the nature of continental hazes suggest themselves. Measurements of atmospheric turbidity should be continued and extended in remote sites. The transport of urban pollution can be studied, among other methods, by the use of high altitude photography. Continuous records of condensation nuclei should be obtained for a number of remote sites.

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[1] Now at University Corporation for Atmospheric Research, Boulder, Colo.

Collected samples of atmospheric haze should be studied to determine the particle size distribution and the chemical constitution. The measurement of carbon-14 content would afford a measure of the urban contribution. Finally, the folk-saying that atmospheric ozone levels are elevated in the lee of large forests should be studied.

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New Discoveries in the Antarctic[1]

D. SHCHERBAKOV

Chairman, Inter-Departmental Commission for the Study of the Antarctic Academy of Sciences, Moscow, U.S.S.R.

In August 1955, it was announced that as a part of the International Geophysical Year program, the Soviet Union would send a complex scientific expedition to the Antarctic. I was asked to write a brochure on the Antarctic and the problems connected with its study. Therefore, I had to do a fast job of generalizing the data on this question. It turned out that though 260 expeditions had visited the area of the South Pole since the discovery of Antarctica, very sparse information has been gathered on this part of the globe. Scientists knew less about the internal areas of the ice continent than about the visible side of the Moon.

Slightly more than five years have passed since then. This is not a long period, but the explorers from 12 countries working in the Antarctic all this time have succeeded in doing a great deal. Soviet scientists attained especially big successes. They set up 10 permanent bases, seven of which are located in the depths of the continent. The numerous data gathered by the five Soviet continental and marine Antarctic expeditions are being thoroughly studied. Although the final conclusions on many questions have not been drawn yet, it can be boldly stated that our knowledge of the Antarctic has been enriched to a great extent. Let us see in what respect.

M. Lazarev, one of the discoverers of Antarctica, dubbed this land 'the ice continent.' It is hard to find a more apt description of the peculiar features of Antarctica, whose surface is almost completely covered by a thick armour of ice. Until quite recently, however, there had been no exact data on the thickness of this cover. For a long time scientists were also unable to answer this question: Is it a mainland or a group of islands differing in size buried under the Antarctic ice shield?

To solve this interesting problem Soviet scientists made measurements of the height of the ice cupola. The observations were conducted from planes and tractor trains in many points of East Antarctica. As a result of all this, the thickness of the ice armour and the structure of the surface beneath the ice from Mirny Station to the Pole of Inaccessibility and from Komsomolskaya to Vostok Station, and then up to the South Geographic Pole were established. Now it can be considered established that Antarctica represents not a group of islands but a continent. Under the ice there is a mountainous land with peaks, cavities and comparatively even surfaces. The thickness of the ice armour ranges from 1000 to 4000 m. The greatest thickness of the ice armour has been found south of Pionerskaya Station, where it reaches 4060 m. Proceeding from this, it can be considered that 25 to 30 million km^3 of ice are concentrated in the Antarctic—nearly nine-tenths of all the ice masses on Earth.

The freezing of our planet is one of the greatest riddles in the history of the Earth. The concrete reasons and laws of this grand natural phenomenon are not known exactly to this very day. But it is important to know them, for only then will we be able to make any long-range forecasts of climatic changes. The investigations on the sixth continent—a tremendous natural ice laboratory—can be of great help here. A study of ice formation in Antarctica helps us to learn about the character of the glacial periods and, possibly, find out the reasons for their appearances. That is why Soviet scientists devote the utmost attention to the problem of whether the ice cover of the South Pole continent is growing or diminishing.

The second Soviet continental expedition repeated the topographical surveys and the measurements of the movement of the border section of the ice at Mount Gauss. It turned out that in the course of 55 years the surface of the glacier in this place dropped by almost 8 m. This means that simultaneously with the other glaciers of the globe the ice cover in this place unquestionably retreated, although much more slowly, than the glaciers of, say, the Alps.

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[1] Translated from *Krasnaya Zvezda*, March 4, 1961.

One source of reduction of the Antarctic glaciers is icebergs. Thus, by repeating the aerial photography of the border of the ice barrier near Mirny that stretches for 600 km., we established that about 50,000 m^3 of ice break off from every kilometer of barrier and flow away into the ocean during one year. However, it is still hard to give a final answer to the question: What takes place in the ice cover of Antarctica? It is necessary to make a thorough analysis of the material that has already been accumulated and gather more.

A detailed investigation of the surface of Antarctica revealed that seven per cent of it is free from ice. Such 'oases' are of great importance for science. They make it possible to gather detailed information on the geological structure of Antarctica's basic rock, and determine the time and character of its appearance.

Much evidence has been received in recent times in favor of the hypothesis that approximately 150 million years ago Antarctica formed, together with South America, Africa, India, and Australia—the ancient Gondwanaland which subsequently was torn apart by powerful tectonic forces. This is where the analogy of the geological structure of separate zones of South America, Africa, India, Australia, and Antarctica suggests itself. It follows, therefore, that the sixth continent must be rich in many minerals—in particular, uranium and thorium ores, diamonds, gold and beryllium.

The first practical confirmations of this hypothesis have already been received. The discovery of coal in a number of places in Antarctica, such as the thick seams in the mountains of South Victoria Land that evidently are part of a huge basin with an area of about a million square kilometers, is of considerable interest.

Some American specialists suggest that there must be oil in the bowels of the sixth continent. Soviet geologists discovered fragments of magnetic quartzites and shales among the glacial deposits in the Banger and Westphel oases, which indicates the proximity of the basic deposits of these rocks.

Many readers already know that the Earth's Pole of Cold is located in Antarctica. On August 24, 1960, Soviet explorers at Vostok Station registered a temperature of −88.3°C (−127°F). No one has ever before met with such cold on the surface of the Earth.

The main part of Antarctica is beyond the Polar Circle. For a long time in winter the sun does not rise. This is what leads to the intense freezing of the surface of the continent's ice cover. At the same time more warmth per unit of surface falls in the summer on the mainland than in the Sahara Desert due to the exceptional dryness and transparency of the Antarctic atmosphere. But why then does not the ice armour in Antarctica thaw and why are big frosts observed even under such in inflow of warmth? This is to be explained again by the presence of the ice cover; almost all the solar heat is reflected by the surface of Antarctica like a mirror, while Sahara, on the contrary, absorbs it almost entirely.

Even quite recently some specialists believed that since the ice continent is deeply frozen, this means that a high-pressure cap always hangs over it, preventing the penetration of lighter warm air masses. This hypothesis gave rise to the idea of the existence of a 'wind barrier' around Antarctica that isolates the atmosphere of the sixth continent from the rest of the Earth. New investigations showed, however, that there are no 'wind barriers' around Antarctica and that its air masses are an integral part of the Earth's entire atmosphere. This conclusion is extremely important. It shows that exact weather forecasts for countries located even in the northern hemisphere cannot be made without taking into account the movement of the Antarctic air masses.

The so-called channel winds are characteristic of Antarctica. Under the influence of the Earth's rotation they assume considerable force in the coastal area of the continent and a steady southeastern direction. The channel winds, sometimes gaining the force of a hurricane, carry with them a tremendous amount of snow and thereby are conducive to the formation of ice. Soviet scientists were the first to establish that in the area of Mirny, for instance, 2.7 million tons of snow were carried through every kilometer of coastline in the course of 1959.

The Southern Ocean—up to this very day

such a geographic name is not to be found on the map. But a number of specialists are already persistently so-calling the huge ringlike spaces of ocean waters bordering on Antarctica.

In these five years Soviet scientists carried out large complex investigations in the Southern Ocean. The expeditionary ships *Ob* and *Lena* covered almost 180,000 miles for scientific purposes, making more than 500 deep-water oceanological tests. It was established in the course of this work that huge areas of the bed of the Southern Ocean are occupied by products of volcanic eruptions—lava. Separate volcanic cones alternate with high mountains and a mass of merged volcanoes. A narrow deep underground rift has been discovered within the coastal part of the ocean bed, which usually has small depths. It runs parallel to the edge of the Antarctic continent at a distance of 30 to 60 miles from it. The rift stretches for 2000 miles from Davis Sea to Victoria Land. Its greatest depth is 1600 m, which is about four times deeper than the near-lying waters. This tremendous fissure is evidently the result of the action of colossal static pressure of the Antarctic glacial shield. Soviet specialists have drawn reliable maps embracing more than a third of Antarctica's coast for the first time on the basis of aerial photography, and marine and hydrographic surveys.

Now the sixth Soviet expedition is working in the Antarctic. It will continue the scientific work on the ice continent and in the waters washing its shores. The construction of a new Antarctic station, Novolazarevskaya, has been completed. Broad-scale exploration of Queen Maud Land, the last of the least-studied sections of Antarctica, will start from there.

Thus, thanks to the joint exploration by scientists of 12 countries, science has learned more about the South Polar region than in the entire preceding history of its study. But the Antarctic still retains a lot of secrets, and scientists will have to work hard and persistently to discover them.

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Weston Magnetic Facility

R. O. HUTCHINSON

Air Force Cambridge Research Laboratories,
Bedford, Mass.

AND

J. POMEROY, S.J.

Weston Observatory, Weston, Mass.

History and Site Selection—A magnetic facility has been established adjacent to Weston Observatory, at Weston, Massachusetts, about 12 miles west of Boston. This new facility is under the sponsorship of the Ionospheric Physics Laboratory, Air Force Cambridge Research Laboratories (AFCRL), and is being operated jointly with the Department of Geophysics, Boston College. The coordinates of the station are: geographic latitude—42°23′06.71″ north; geographic longitude—71°19′15.08″ west; geomagnetic latitude—53°54′; geomagnetic longitude—357°05′; elevation above sea level, 57.7 meters.

Construction of this new magnetic observatory was undertaken initially to fulfill the special requirements of AFCRL for a calibration and test operation site in connection with an aeromagnetic survey program. It is now being operated as a test station for a rocket and satellite magnetic measurement program.

The site affords a large protected area in a residential town that is unlikely to be affected by industrial expansion, and only a few miles from the Cambridge Research Laboratories. An aeromagnetic survey performed at the site with a NOL VAM-2 magnetometer flown at minimum altitude, covered an area about 6 miles in radius. It showed that the proposed site was situated on a small positive anomaly with gradients of about 80γ per mile in all directions. Total intensity surveys were then conducted over several hundred acres of Weston College property adjacent to the Observatory. A geologic survey and a multi-level magnetic survey were also made (Reference 1). Formal operation of the observatory began in February 1960.

Instrumentation—Observatory magnetometers and associated equipment were installed in order to provide proper references for rocket instruments. In the process of providing these references it was determined that the facility met all of the requirements of a first-class magnetic observatory.

A Varian Associates proton precession magnetometer was modified to increase the signal amplitude, and the sample and coil were placed on a non-magnetic tower. This unit—our current standard for measuring total intensity—will soon be replaced by an alkali vapor magnetometer that is now undergoing operational and comparison tests at the facility.

Horizontal intensity, vertical intensity, and declination are recorded continuously; two sets of Ruska Instrument Corporation variometers are being used to provide for high and low sensitivities, as recommended by the United States Coast and Geodetic Survey (Reference 2). Standard photographic recordings are made on 24-hour drums, and sensitivity is checked regularly with Helmholtz coils. A Chernosky-Vestine variometer using a variable-area recording technique on 70 mm film is also operated.

Baseline values for the variometers are determined from the proton precession magnetometer used in conjunction with a Ruska observatory model Inclinatorium and Theodolite magnetometer of standard USCGS design. An Askania Universal Torsion magnetometer is also available for rapid determinations of H, D, and Z.

The buildings that house the variometers and absolute instruments are constructed of non-magnetic materials and are located at least 200 feet from any other facility. Stability of temperature is maintained by a thermostatically controlled electrical heating system.

The instrument piers in the variometer and absolute instrument areas are constructed of cement blocks topped with marble slabs. The blocks and mortar were carefully chosen to be as free as possible from magnetic impurities.

Operations—The primary purpose of the observatory is to serve as an assembly area, a test station, and an absolute calibration site for instrument packages to be used for making magnetic measurements in space. In order to maintain a high standard of control, records are changed, processed, and read daily. All original records are stored at the observatory for possible further use. Future operations of the observatory will be geared to the special needs of the space field measuring program.

A magnetic bulletin is published quarterly by Weston Observatory. It contains hourly mean values of declination, horizontal and vertical intensity, and absolute total intensity, and will be available about three weeks after the expiration of each three-months' period. The first bulletins were issued in February 1961, for the periods July-September and October-December 1960. Data will be available to qualified personnel, and exchange of bulletins is invited. Inquiries should be addressed to Weston Observatory, Weston 93, Massachusetts.

The initial operation and installation of the observatory was undertaken through contract AF19(604)3504, AFCRL and Weston College. The current operation of the observatory is supported in part by contract AF19(604)5569, AFCRL and Boston College.

REFERENCES

1. *Final Technical Report, Contract AF19(604)-3504,* Weston College, April 1960
2. McComb, H. E., *Magnetic Observatory Manual,* Special Publication 283, U. S. Dept. of Commerce, 1952, p. 134

Reviews

FRITSCH, V., *Elektrische Messungen an raumlich ausgedehnten Leitern* (Electrical Measurements of Volume Conductors), Verlag G. Braun, Karlsruhe, Germany, xii & 372 pp., 1960, DM45 (a treatise with special reference to applied geo-electricity).

The author of this text has had years of practical experience dealing with electrical probing of geological materials. It is very fortunate that he also has a keen insight into the physical principles involved. This book is a comprehensive treatment of the whole subject of geo-electricity. Since no comparable text has been available the present book fills a definite need.

Many of the methods discussed are variations of the four-electrode technique which is based on potential theory. The influences of stratification, inhomogeneity, and anisotropy of the underlying structure are discussed in considerable detail. It is shown that, by varying the electrode spacings and configurations, certain of these features can be singled out for special consideration. The required circuit arrangements for effectively carrying out such measurements *in situ* and in the laboratory are described very adequately. The advantages and complications that arise when alternating currents are used for source excitation are also covered thoroughly. In later chapters of the book, the related inductive methods are also discussed, though somewhat less completely.

Several chapters are devoted to radio wave methods in geological mapping. Here the theory presented is quite crude, and many of the simplifying assumptions require justification. Nevertheless, the subject matter is very provocative and should stimulate further research in this area.

Many examples of field measurements are cited. A wealth of data on the electrical properties of geological materials is included, and much of this information is given in convenient tabular form.

The book contains an exhaustive bibliography on the literature of geo-electricity and related subjects. It is interesting to note that many of the recent papers in this field are by Russian authors.

James R. Wait

M. J. AITKEN, *Physics and Archaeology*, Interscience Publishers, Inc., New York, 181 pp., 1961.

Two broad subjects of interest to Earth scientists are discussed, geophysical prospecting and dating. As the differences between the methods used in archaeology and geology are largely a matter of scale, this excellent, up-to-date treatment should also be of considerable interest to many geophysicists and geologists.

Two principal prospecting methods are discussed: resistivity surveying and magnetic location. The magnetic method appears to be somewhat more useful in archaeology than is the resistivity method, and the treatment accorded the magnetic method here is exceptionally complete, ranging from the theory of the proton magnetometer to practical schemes for laying out a sampling grid. A circuit diagram is given for a special prospecting proton gradiometer that utilizes the beat frequency generated by two bottles separated a distance of 5 feet. Typical of this book's thoroughness and usefulness, sufficient details are given to enable the reader to construct this instrument. Case histories illustrate how the method has located many archaeological sites.

Most dating methods are surveyed, including dendrochronology, varve counting, pollen analysis, special methods for dating bone, and thermoluminescence. Carbon-14 dating is given an exceptionally thorough, balanced treatment. Almost everything of interest to the user of this method is reviewed, including the measurement of the radioactivity, the factors that limit the maximum age of datable material, the cost of analyses, the locations of the laboratories that make analyses, and the complications that may affect results, including variations in the size of the exchange reservoir, mixing with the reservoir, the fossil fuel effect, variations in cosmic ray intensity, and isotopic fractionation.

The chapter on the dating of archaeological objects made of baked clay by means of their remanent magnetization is certainly the most thorough and up-to-date account of this rapidly developing technique now available in English. The way in which baked clays acquire thermoremanent magnetization, and other magnetizing processes that may alter the original thermoremanent magnetization after baking, are well reviewed. Collecting and measuring techniques adapted especially to archaeological use are described with many useful details. The treatment of the technical part of this field is complete and up to date with one minor exception, that is, the advances in partial demagnetization technique that have been made by Creer and by As and Zijderveld are omitted. On the problem of interpretation of paleomagnetic data in archaeology, both the usefulness of the method and its limitations are stated clearly. Some interesting new results by the group at Oxford University are presented; these extend our knowledge of the geomagnetic secular variation in England back to 600 B.C.

Allan Cox

L. V. BERKNER, AND HUGH ODISHAW (EDS.), *Science in Space*, McGraw-Hill, New York, 458 pp., 1961, $7.00.

This book is addressed principally to those professional scientists who are concerned with, or interested in, the use of rockets, satellites, and space probes for the scientific investigation and exploration of space. The general layman would probably be hard put to make much out of it; the professional will find the book both interesting and useful.

The book is divided into eight parts, in which twenty outstanding authorities discuss major areas in space science. The style of writing differs from part to part, as would be expected from the long list of contributors. Nevertheless, the editors have succeeded in calling forth from the different authors a high degree of clarity.

The depth of treatment varies from subject to subject. Although all of the discussions will be found useful, some are disappointingly brief. Whereas fields and particles in space, and the stars, are given extensive treatments, the Earth, and especially the Earth's upper atmosphere, hardly receive the thorough discussion they deserve.

Each chapter contains a helpful list of references and suggested supplemental reading.

Part I is called *A General Review*. In the first chapter, entitled 'Dimensions and Problems,' the editors set the stage for the discussions that follow. They point out that the availability of large rocket vehicles now makes it possible to pursue a vigorous program of exploration, practical application, and research, and each of these three topics is discussed at some length. The authors provide also a brief review of the space vehicles that are available or under development. They urge that the United States space effort place particular emphasis upon the conduct of important experiments in space, that the effort be supported by a broad and extensive program of underlying basic research, and that the best creative minds everywhere be drawn into the program. In conclusion, they point to the international scope of space activities, reviewing the role of the International Council of Scientific Unions and its Committee on Space Research (COSPAR).

In a chapter entitled 'Results of Experiments in Space', Bruno Rossi and Robert Jastrow give an excellent review of results obtained to date from both the United States and USSR space programs. The authors point out that there are four different scientific uses of space vehicles, namely: (1) to investigate particles and fields in the distant regions of space, (2) to study our own planet, (3) to make astronomical observations in the spectral regions hitherto inaccessible to us, and (4) to explore the other planets and the Moon. In areas 1 and 2 much progress has been made. The authors discuss both areas at length. In areas 3 and 4 not much has yet been accomplished, although some beginnings have been made; the USSR has made measurements in the vicinity of the Moon and secured photographs of the back surfaces of the Moon, and the United States has made a good beginning in rocket astronomy.

Part 2 consists of a single chapter on *The Nature of Gravitation*, in which R. H. Dicke reviews current thinking and gives a lucid presentation of the major questions concerning gravitation and possible secular changes in the gravitational constant.

Part 3, *The Earth*, includes a discussion of geodetic problems and the requirements of an ideal geodetic satellite system, by George P. Woollard; a chapter by Harry Wexler on the uses and importance of rockets and satellites for meteorological studies; a brief chapter by W. W. Kellogg, on 'Rocket Research and the Upper Atmosphere'; and a discussion of 'Satellites and the Upper Atmosphere', by A. H. Shapley and O. G. Villard, Jr., in which the uses of satellites, the major problems involved, and the possible types of satellite experiments are treated.

Part 4, *The Moon and the Planets*, is by H. C. Urey. After giving a review of our knowledge of the Moon, the author lists ways in which a satellite of the Moon could be used for making measurements of radioactivity, mass distribution, density and composition of the lunar atmosphere, and the lunar magnetic field. He also discusses the separate and specific functions of hard and soft landings for making various kinds of observations. The second chapter of Part 4 deals with the study and exploration of the planets, pointing out particularly the kinds of observations that should receive early consideration.

In Part 5, *Fields and Particles in Space*, is presented an extensive review of what has become a major area of activity in space science. Three chapters by J. A. Simpson and one by E. N. Parker bring out very forcefully the great strides that have been made and are being taken with ground-based and balloon-based observations, and theory. The magnetic fields and particles in space, the acceleration and propagation of particles within the solar system, and the solar modulation of cosmic radiations and other energetic particles that reach the Earth are discussed at some length. 'The Geomagnetically Trapped Corpuscular Radiation' is discussed in another chapter by James A. Van Allen, who discovered this radiation in the early Explorer satellites. Observations obtained from Explorers I, III, and IV, and Pioneers III and IV, are presented and discussed. This part of the book is completed by a chapter on 'Particles and Fields Pertinent to Auroral Theory', by J. W. Chamberlain; the chapter contains a very brief review of various theories concerning solar particle emissions and their possible connection with the auroras. The principal problems concerning the origin of the auroras are reviewed.

Part 6, *The Stars*, consists of two chapters, both by L. Goldberg and E. R. Dyer, Jr. The first is a concise but thorough review of what is known about the Sun. The authors provide a lengthy list of unsolved problems, and follow this with an even longer list of investigations that may be undertaken, with rockets and satellites, to solve some of the existing problems. The second chapter on 'Galactic and Extragalactic Astronomy', is organized in much the same way as the chapter on the Sun, providing a very useful review of current knowledge and theory, and existing research problems.

Part 7, on *The Life Sciences,* opens with a very brief chapter on the 'Biological Sciences in Space Research', by Joshua Lederberg and H. K. Hartlein, which points to the opportunities for bioscience experimentation now provided by space vehicles, and to some of the hazards involved, such as the likelihood of contaminating extraterrestrial bodies with terrestrial organisms, and the possibility of back contamination of the Earth by planetary organisms carried by a returning spacecraft. These opportunities and potential hazards are discussed at greater length in the following chapter, 'Exobiology: Experimental Approaches to Life Beyond the Earth', by Joshua Lederberg, in which the author discusses motivations and objectives of exobiological research, the biochemical aspects of life as we know it on Earth, theories of the origin of life, and the question of panspermia. In the search for extraterrestrial life Mars is the likeliest target. Because microörganisms are almost certain to be anywhere that macroörganisms may be found, whereas the converse is not necessarily true, the first line of attack would be to search for such microörganisms. The author describes a possible automatic microscope system that might be used on a planet such as Mars. He concludes with a discussion of the hazards mentioned above.

Part 8 describes the composition and functions of the Space Science Board, and its relation to government agencies, such as the National Aeronautics and Space Administration and the National Science Foundation.

Science in Space is a product of the Space Science Board's activity in keeping the scientific community informed about progress and problems in the ever widening fields of science in space. It is necessary reading for those participating in, concerned with, interested in, or in any way responsible for the U. S. program in space science.

Homer E. Newell

Carl Eckart, *Hydrodynamics of Oceans and Atmospheres,* Pergamon Press, New York, xi + 290 pages, 90 figures, 1960, $9.00.

This book treats a class of hydrodynamical problems related to stratified fluids, the stratification giving a stability which influences the possible forms of motion. Such stratification is characteristic for the atmosphere and for the ocean, mainly in connection with the vertical distribution of pressure and temperature, the relation between density and vertical coordinate being different, of course, in the two cases. A discussion of the mathematical aspects of this class of problems of fluid motion was given by Dr. Eckart (in cooperation with H. G. Ferris) in 1956, (*Reviews of Modern Physics,* vol. 28, pp. 48–52) which still can serve as a very useful and lucid introduction to the book, defining both its objectives and the limitations which the author has set himself. As Dr. Eckert observes, a considerable literature on the motion of stratified fluids has accumulated, including the theory of convection as well as the theory of waves in such media. However, little effort has been made to systematize the existing theories, and comparison of different papers is made difficult because of differences in the basic equations and simplifying assumptions. Dr. Eckart's objective is to collect the major systems of equations (this is done both in the paper referred to above and, more extensively, in this book), and to discuss the relations between the various assumptions that have been applied. The special purpose of the book, then, is to present a systematic account of the solutions that can be constructed.

The limitation to this class of problems excludes the treatment of many other problems of importance in meteorology or oceanography, such as the motions that can occur in a sea of limited extent, under the action of a given wind system, combined with tidal motion. Lateral boundary conditions introduced by geographical limitations are not investigated; the book has some scattered references to the influence of such boundary conditions (see chapter VI and section 59 of chapter X), but in section 35 of chapter VII (p. 89) it is decided to consider only those cases in which the fluid is bounded by level surfaces. Thus the effect of the continents on oceanic currents and tides, and the effect of terrain on atmospheric phenomena, are left aside. Also there is no discussion of empirical data concerning wind friction, of heating by solar radiation, or of turbulence. The author is aware of the limitations he has set to his subject in this way, and on page 1, chapter I, he states that the objective of the book is to illustrate the laws of dynamics, whereas the final step, that of introducing empirical data into the calculations and comparing the result with observation, is usually not attempted. Both the atmosphere and the ocean are treated as simple fluids, the effects of turbulence and of viscosity have been left out of view, the heating of the atmosphere by solar radiation is discussed in a summary way only, and no attention is given to local changes in the density of the sea water that may occur at places of influx of fresh water. Dr. Eckart says in the Preface: "The greater part of this book could have been written fifty or sixty years ago; it is inevitable that the book will seem anachronistic to many readers". Nevertheless, Dr. Eckart is right in his conviction that the systematic treatment of the classical problems connected with stratified fluids, clearing away the existing confusion and bringing various new results, is of much importance. It is also his belief that, even with the limitations accepted, a wider range of topics can be analyzed than is usually supposed. Although certain problems analyzed by Dr. Eckart may find a counterpart in the *Physikalische Hydrodynamik* by V. Bjerknes and others (1933), there is no obvious connection, and Eckart's book, although much more restricted in scope, is also more homogeneous and lucid.

The main contents of the book start with a discussion of the basic equations (the vectorial equation for the acceleration; the equation of continuity; the thermodynamic equation), and then deduces the first order perturbation equations (p. 18). These first order perturbations are transformed by the introduction of a special system of 'field variables' (p. 55), convenient and elegant from the mathematical point of view, but not so easily visualized as physical quantities. For this part of the book the summary given in the article in the *Reviews of Modern Physics* (cited above) is very helpful. Chapters VI and VII of the book present some general theorems concerning the field equations, and formulate the major mathematical problems. The equations have terms on their right hand sides that depend upon extra forces and accession of heat, but attention is given mainly to the 'free solutions' (as defined p. 84), for the case where the right hand sides are zero. Two methods of attack are applied: on one hand, eigensolutions are constructed and discussed, and on the other hand the propagation of waves and the associated systems of rays are investigated. Attention is given to the relation between the results obtained with these two methods.

The equations are discussed for various cases, of which the most important are plane level surfaces and spherical level surfaces, each with and without rotation. It is here that the main importance of the book lies. Much space is devoted to diagnostic diagrams, displaying the properties of solutions in various domains of parameter values, and to discussing them. It is difficult to give a concise analysis of the contents, and it may be sufficient to quote a few particular topics: isothermal atmosphere (chapters VIII, IX, with a discussion of Lamb's waves and gravity waves, and a reference to the possible connection of gravity waves with wind fluctuations, pp. 120/121); oceans with constant coefficients (chapter X); the thermocline in the ocean (chapter XII); the thermosphere (chapter XIII); an atmosphere with a single temperature minimum (section 88, p. 237); Rossby waves (p. 278). The theory of rays starts with chapter XI, p. 154; here much attention is given to the method of approximation that is associated with the names of Wentzel, Kramers, and Brillouin in quantum mechanics, which method is applied in this and in subsequent chapters with great clarity.

The book does not have a list of the notations used, although some notations are referred to in the index. This makes it difficult for a reader to obtain a rapid view of some particular topic; he has to refer back to previous chapters and equations in order to find out what the various letters mean. A curious case is presented by the letter N, first occurring on p. 55. It is not given a name in the text, but in the Preface, p. xi, the name 'Väisälä-Brunt frequency' occurs for N, whereas the index has the entries 'Brunt frequency; see N' and 'Väisälä frequency, see N'. There is then a separate entry for N with between brackets 'stability parameter'. Why is this name not given at once on p. 55? More cases can be cited wherein the author, no doubt through long years of use, has his notations so much in his mind, that he forgets that a reader will be happy to have a precise definition; so, for instance, on p. 8, where it is stated: "The 'gravitational altitude', χ, may, to an accuracy sufficient for the present purpose, be considered equal to the vertical coordinate . . .".

There are a few errors of print, but the book is well prepared and is well cared for by the publishing firm. The investigations presented in it are of great interest, but perhaps mostly for the mathematical physicist.

J. M. Burgers

C. E. Wallington, *Meteorology for Glider Pilots*, John Murray, Ltd., London, 284 pp., 1961.

In writing a book to help glider pilots in England understand and utilize the weather for soaring, Mr. Wallington has had to give strong emphasis to the fundamentals of weather. The result is a book of interest to many other people in addition to soaring enthusiasts.

The first nine chapters cover meteorological fundamentals in clear, concise style. The rest of the book elaborates on those factors that are particularly relevant to soaring flight. It makes use of the latest theories on such subjects as waves, the sea breeze, and cumulus convection, and also of some theories not yet proved. Where appropriate, the author even includes such diverse subjects as altimeter setting in airways, long range forecasting, and glider and winch safety in lightning.

The book is well illustrated with photographs and diagrams. It is compiled as a complete text book, and as such includes a bibliography, a subject index, and conversion factors. The few formulas presented are simple. Mr. Wallington states the level of the book was determined to be suitable for self-tuition, to emphasize fundamentals so that the pilot may comprehend the weather he encounters, and to serve as a textbook for courses in gliding meteorology.

To keep the book down to a manageable size (284 pages) and at the same time to make it as accurate as possible, Mr. Wallington has limited the subject matter to the sorts of conditions encountered in the British Isles. Fortunately, the fundamentals of storm systems, thermals, and waves tend to be the same the world around, so the book is pertinent for pilots everywhere. Inasmuch as the author emphasizes throughout the fundamentals behind the weather phenomenon under consideration, and as only a small proportion of the book is devoted to the specifics of soaring flight, the book can actually double as an introduction to general meteorology.

Paul B. MacCready, Jr.

M. E. Al'tovskii, Z. L. Kuznetsova, and V. M. Shvets, *Origin of Oil and Oil Deposits*, Published in Russian, 1958; English translation, Consultants Bureau, New York, 1961.

This book presents data collected for, and conclusions reached by, a committee during five years study of the organic substances present in underground waters in petroleum and non-petroleum provinces, and of the bacteria present in those waters.

There are three chapters in the book:

(1) General questions on the origin of oil. Considering the scope of this chapter, a more explicit title would be: General findings as to origin, diagenesis, migration, and entrapment of petroleum and natural gas.

(2) A brief survey of the hydrogeologic conditions in the Grozny and Dagestan region and the contents of organic material in the ground water.

(3) Results of microbiological investigations (in the same region).

Chapters 2 and 3 are progress reports and to review them orientation maps and other materials would be necessary. This review therefore will be limited to Chapter 1—74 pages—with supporting data quite brief, and the review will present the book's theses concerning incidents postulated as part of the history of petroleum deposits, and will parallel that presentation with the orthodox American viewpoint as formulated in the following publications: L. G. Weeks (ed.), *Habitat of Oil*, Amer. Assn. Pet. Geol., 1958; W. E. Hanson, *Origin of Petroleum*, Chap. V, Chemical Technology of Petroleum 3rd ed., McGraw-Hill, 1960.

The first incident reported concerning petroleum is the formation of a source material, which in the book is attributed to 'accumulation of land-plant remains in subsurface' (pp. 18 and 24), that is, the percolation from a vegetation-covered land area into a porous and permeable outcrop below the soil. This accumulation accompanies the infiltration of meteoric water. The outcrop could be that of rock layer (aquifer) having an origin either continental or marine and a texture of either clastic grains or crystal growth.

On page 72 is the statement: 'The oil is thought to have formed in ground water.' This sentence applies not only to preservation of the source material, but also to the next two incidents: migration and diagenesis. The Russian view is that migration is through a sloping aquifer, the same in which it has percolated, and the same which will be the reservoir some distance away for the oilfield; that the organic material passes through the successively deeper zones of bicarbonate, sulphate, and weaker chloride waters, in all of which it is subject to bacterial action and other diagenesis such as alpha radiation, but that once it has reached deeper aquifers, brines of high chloride content, bacteria are inactive (p. 7). It is therefore the view that only the outcrop and the aquifer itself contribute to the formation of petroleum, and the aquicludes which bound it contribute nothing.

The parallel American view consists of the following: the first incident is the accumulation of organic material from flora living in brackish water or seawater into the bottom muds of the water body [Hanson, p. 229]; from the muds, fluids migrate to the nearest aquifer as a result of mud compaction; there is also possibly later migration, perhaps of hydrocarbons only, through joints and fault planes. These movements obviously can be either up, down, or lateral. Therefore the American view looks much at the permeability of the aquicludes.

By no means, however, has the Russian mechanism of migration been disregarded in American literature. *Munn* [*Econ. Geol.*, **4**, pp. 509–529], *Rich* [*Econ. Geol.*, **16**, pp. 347–371, 1921], and *Hubbert* [*Bull. Amer. Assn. Pet. Geol.*, **37**, pp. 1954–1981] have illustrated the hydrodynamics in downward-sloping aquifers. This energy-source explanation is not new in Russia [*Uiks, Petroleum Economics, no. 8*, 1926].

American authors seem to lean to the view of major diagenesis early in the history, before much fluid movement.

As to the last incident in collection of petroleum, Russian and American views concerning entrapment agree.

Examining examples cited of sample collecting and of analyses, the reader must be impressed by collections farther away from oil fields, and by analyses more specialized than those available to research workers in this country. As in the work of Ginzburg, Vinogradov, and Kartzer and his associates, there is evidence of the substantial manpower available to the directors of such studies as set forth in the book under review.

The book fulfills the claim in its preface: 'designed not only for hydrogeologists, but also for geologists, chemists, and microbiologists.' As to the hydrodynamical relish in it, readers will recognize the senior author as author of *The problem of chemical evolution of ground water*, [1950].

We have three different ideas concerning sources for the hydrocarbons: (1) Inorganic for at least a part [for example, *Kropotkin, Soviet Geology*, **47**, 1955]; (2) From marine flora principally [*Hanson*, p. 228]; (3) From land flora, the thesis of this book, strongly advocated by *Cunningham-Craig* [*Oil Finding*, Arnold, London, 1915, 2nd ed., 1923].

This book utilizes hydrodynamic mechanics, and also chemical studies *ad hoc* not commonly available to hydrologists and geologists, and therefore its perusal is very challenging.

Paul Weaver

WALTER H. MUNK AND GORDON J. F. MACDONALD, *The Rotation of the Earth: A Geophysical Discussion*, Cambridge University Press, xix + 323 pp., 1960, $13.50.

This timely book provides a needed summary of a subject which has received increasing attention during recent years. The title is used with the general dynamical meaning of the motion of the Earth relative to its center of mass, not in the restricted sense of only the angular motion around the axis of rotation; as the subtitle implies, the book is devoted to the effects caused by the departures of the Earth from a perfectly rigid body. The first chapter is a brief outline of the contents.

The motion of the Earth relative to its center of mass, which is qualitatively described in the second chapter, is a complex resultant of three components. While rotating around an axis that always passes through the center of mass but does not coincide exactly with the axis of figure, the Earth is continually changing its position slightly relative to the axis of rotation; the axis of figure describes an irregularly variable conical surface in space around the axis of rotation without appreciably changing the direction of the axis of rotation. Consequently, the axis of rotation lies in successively different positions on a conical surface within the Earth, and the geographic poles move over the surface of the Earth. Concurrently, under the gravitational attractions of the Sun and Moon, the axis of rotation has a conical motion in space, in which the Earth participates as a whole without any change in its position relative to the axis; the secular component is the lunisolar precession, and the periodic components constitute nutation.

All three motions are affected by the deformations of the Earth, and the transport of mass in the atmosphere, the oceans, and the interior of the Earth, that occur in geophysical phenomena; but the determination of the effects is a problem of the utmost difficulty. These effects cannot be calculated from theory, but must be determined from observations. Their evaluation by the analysis and interpretation of observations is a valuable means of investigating the geophysical causes; but with few exceptions, the observed effects have not been completely explained, and cannot be satisfactorily represented by quantitative theories.

The lunisolar motion of the axis of rotation in space has not been shown with certainty to be affected to a degree that can be detected by observation; but the motion of the geographic poles is greatly different from the motion that would occur were the Earth rigid, and the rate of the diurnal rotation has appreciable periodic, irregular, and secular variations. It is to a unified discussion of the polar motion and the rate of rotation that the book is devoted. The general dynamical theory of the motion of a rotating deformable body, and the theory of the deformations of the Earth under stress and their effects on the rotation, are given in the four chapters, covering 49 pages, that follow the two introductory chapters. The next two chapters, filling 32 pages, describe the observations by which the polar motion and the variations in rotation are determined.

The next three chapters, comprising 160 pages, summarize the accumulated observational data, discuss in detail their analysis and geophysical interpretation, and critically review previous theoretical investigations. It appears that every conceivable influence which possibly might affect the polar motion or the rate of rotation is considered, with a quantitative estimate of its effects, on a dynamical basis as far as possible.

A final chapter of 36 pages discusses the wandering of the poles which may have occurred during geologic ages. The geologic evidence formerly available for the solution of this problem has recently been augmented by paleomagnetic data; this has reopened the subject, but the authors end their discussion with the statement, "Our principal conclusion is that the problem is unsolved."

The polar wandering in geologic time is not the only problem in which a similar conclusion is reached. Throughout the book, many incompletely solved or entirely unsolved problems remain. The results of many original researches of the authors are included in the discussion; they often disagree with previous investigations, and in the Preface the authors remark, ". . . we expect new problems to be posed and solved problems to be unsolved at an accelerating rate."

Two brief mathematical appendices, 17 pages of references to the literature, and an index complete the book.

Edgar W. Woolard

UNITED STATES GEOLOGICAL SURVEY, (Staff Members), *Geological Survey Research 1960*, U. S. Geol. Survey Prof. Paper 400, 1961; *Part A, Synopsis of Geologic Results*, 136 pp., $1.00; *Part B, Short Papers in the Geological Sciences*, 515 pp., $4.25.

During recent decades the marked growth of the Geological Survey and the steadily increasing diversity of its activities have made it more and more difficult to publish promptly the results of completed work. Vigorous efforts to solve this problem have been reflected in a trend toward shorter reports and the release of basic data in the form of maps with or without accompanying brief texts. Professional Paper 400, frankly presented as a new experiment in Survey publication, is a logical and praiseworthy element in this trend, even though it cannot be termed a short report!

Issued in two chapters, this volume is concerned essentially with recent activities of the

Geologic Division; expansion to include work of other Divisions of the Geological Survey is tentatively planned for future volumes. Chapter A, prepared under the direction of V. E. McKelvey, is a 73-page summary of research activities and results, together with lists of investigations in progress and a list and subject classification of publications by members of the Geologic Division during fiscal year 1960. The text is well organized and individual topics are succinctly presented, a combination that plainly reveals what things are being accomplished and who is responsible for each. Moreover, this is no mere catalogue for piecemeal reference—it is pleasurable reading that tells, without embellishment, the current story of a great organization.

Chapter B, which is much longer, comprises 232 short papers that range from outlines of new ideas and discoveries to summaries of lengthy investigations that have already been completed. The order of presentation is in part topical and in part geographic. A subject-and-author index provides easy access for the reader who has specific interests. The articles themselves are expanded abstracts in the best sense; nearly all of them are highly informative, and many are effectively illustrated. They are particularly recommended for the person who needs up-to-date information on a given topic or area, and for the person who likes stimulation while browsing. The latter is likely to browse longer than he intended, for this tome, once opened, is not easily put down.

Professional Paper 400 is certain to be enthusiastically received by geological scientists everywhere. It should be extremely useful to many, and of real interest to all. One can guess, however, that it was not prepared without great cost to the Geological Survey, notably in terms of time spent by the many individuals involved. One can guess also that opinions among these persons differ as to the merit of interrupting their regular work to prepare 'progress reports.' The decision to publish this volume was courageous, and the Director and Staff of the Geological Survey rate both thanks and congratulations for the excellence of their product. It is to be hoped that additional valuable contributions of this type will appear in the future—if not annually, at least at intervals of five years or less.

Richard H. Jahns

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Notes and Personalia

Notes

- **Corrigendum**—J. J. Levallois has called attention to an error in the account of the Helsinki session on Geoid as reported in *Transactions* for December 1960 (volume 41, no. 4), page 566. The editor regrets that a line in the original copy inadvertently became omitted in proof. The following correction should be made: line 34, column 1, and following should read '. . . same geoid waves. Vogel determined the depth of the Earth's core by travel time of seismic waves, and found a strong correlation. . . .'

- **Corrigendum**—On page 170 of June 1961 *Transactions,* (in *The State of the Earth Sciences in South America*) it was stated that ' A German meteorologist, Albert Müller, is acting as technical advisor'. The reference is in error; the technical adviser is Dr. Albert Miller of the United States Weather Bureau, who was sent to assist Chile in the development of meteorological services, and the program mentioned was established under his guidance.

- **Magnetic Profiles Across North Pacific Object of Scripps Expedition**—The Japanyon Expedition of Scripps Institution of Oceanography is due to end with the docking of Research Vessel *Spencer F. Baird* at San Diego, California on September 18, after a voyage of more than three and a half months to Honolulu and Tokyo. The principal objective was to obtain magnetic profiles across the North Pacific, and especially to obtain a profile just south of the Murray fracture zone from San Diego to longitude 157 degrees W., to establish the amount of striated magnetic anomaly and its orientation between Honolulu and Tokyo, and to establish the location of the Mendocino fracture zone west of longitude 180 degrees.

Three weeks of investigations in the vicinity of Tokyo and Sagami Bays along the south coast of Honshu were for the purpose of studying details of the submarine canyons, which appear to have been cut into rock and to have the dendritic pattern characteristic of land canyons. During part of this time a coordinated program was carried on with the Japanese oceanographic research vessel *Umitaka-Maru*.

The return trip from Tokyo to San Diego followed a more southerly course, along which a magnetic intensity profile was plotted and gravity or piston cores were taken at spacings of 50 to 200 miles.

• Layer of Micrometeorites Encircles Earth—The U. S. Air Force has announced discovery by the Cambridge Research Laboratories (AFCRL) at Bedford, Massachusetts that a dense band of micrometeorites envelopes the Earth at some altitude between 47 and 102 miles. AFCRL hopes to determine the exact altitude in the near future by means of a specially instrumented rocket.

The special nosecone that trapped the micrometeorites was launched June 6 at White Sands, New Mexico. It consisted of a pod-like arrangement made up of individual petals, which opened at an altitude of 47 miles, was carried to 102 miles, and closed again at 65 miles during the descent. The micrometeorites passed through two mylar film layers and struck a third layer—a ⅛ inch thick sheet of plexiglass—on which visible craters were formed.

Few micrometeorites were collected because most of them vaporized on contact with the detecting surfaces. Residual bits of meteorite material lined the walls of the craters; they will be analyzed by radioactive and other laboratory techniques, for the most part by electron microscopy because many of the particles are smaller than the wavelength of light.

A large number of samples are available and AFCRL will furnish these to interested, and qualified, scientists.

The special nosecone was designed by scientists and engineers of AFCRL and the Aerojet General Corporation.

• New Research Group for Space Studies—The National Aeronautics and Space Administration (NASA) is establishing a theoretical research group in New York City, to be known as the Goddard Institute for Space Studies. It will be attached to the Theoretical Division of the Goddard Space Flight Center, a unit of NASA located near Washington, D. C. Robert Jastrow, Chief of this Division, will also head the new group. About fifty scientists from the fields of astronomy, physics, and the Earth sciences will comprise the full-time staff, and additional scientists from nearby universities will serve as part-time consultants. The new Institute began operations in May, and will reach full operation stage by the end of the year. Research areas of major interest will include the structures and atmospheres of the Earth, the Moon, and other planets; Sun-Earth relationships; origin and evolution of the solar system; properties of interplanetary plasma; astrophysics; and celestial mechanics. The program includes also seminars and series of special lectures by prominent scientists.

• Nation's Needs in Science Forecast by NSF—In a recent report, *Investing in Scientific Progress*, the National Science Foundation analyzes the trend in science education since 1920, and projects the needs in subsidization to 1970, if the Nation's future well being is to be safeguarded. The report notes that during 1961 the Nation (all sources) invested $3 billion in colleges and universities for scientific and engineering education, and for basic research; if the goal is to be achieved this investment must grow to $8.2 billion by 1970. This represents a *per capita* rate increase of approximately 2½ times the present rate. The goal to be satisfied is that of developing fully the resource of potential scientific talent as indicated by the increasing numbers of talented young people who desire to follow a career in science.

The report points out that, although the investment is made by private individuals, non-profit organizations (including colleges and universities), industry, and government agencies, the proportion to be furnished by the Federal Government must rise. It is pointed out further that colleges and universities currently have a deficit of about $300 million worth of scientific teaching equipment and $500 million worth of laboratory buildings. Besides these deficits, they will need an average of $560 million annually (through 1970) to take care of expanding needs in these teaching facilities; this does not include funds for adequate research equipment, which, in 1970 will rise to $180 million.

If the major goal as stated above is accepted, and the required funds are made available, the number of people receiving science and engineering doctorates in 1970 will be double the 1961 number.

• Deepest Suboceanic Heat Flow Measurements—The first heat flow measurements ever made 500 feet below the ocean floor have been reported from the preliminary 'Moho' drilling operation near Guadalupe Island, according to the National Research Council. Temperature readings obtained from that depth are somewhat higher than had been expected; at 140 feet below the ocean floor the reading was 7 degrees (Centigrade), and at about 500 feet below a reading of 24 degrees was obtained, making a gradient of 17 degrees Centigrade in approximately 360 feet. These measurements were made in the deeper sediments, probably not more than 60 feet above the basaltic 'second layer' of the oceanic crust.

Geophones and seismic wave detectors were also lowered into the hole. Preliminary analysis of the readings indicates that sound waves penetrate the soft sediment at a rate of 1.59 kilometers per second. This is considerably lower than ordinarily assumed, so that, if the value is generally indicative, oceanic sediments could be thinner than has been supposed.

• **Annual World Meteorological Day**—The World Meteorological Organization (WMO) has decided that March 23 each year should be celebrated as World Meteorological Day, according to an announcement made by the United Nations Educational, Scientific, and Cultural Organization (UNESCO). The object of the designation is to make better known to the general public the services that meteorology provides for the welfare of modern man. Besides weather forecasting—of importance to aircraft pilots, farmers, and seamen, as well as to the man in the street—the science of meteorology has practical applications in public health, transportation, peaceful uses of atomic energy, satellite and rocket research, and other fields. WMO plays an important part in the exchange of world-wide information on forecasting, and helps to standardize instruments and methods. It also carries out projects requiring international action, such as development of water resources, tropical and arid zone research, and studies of the atmosphere.

• **Symposium on Plant-Environment Relationships**—The Botanical Institute of the University of Montpellier proposes to organize an international symposium on research techniques involved in the study of plant-environment relationships, with special reference to their application in arid and semi-arid regions. The symposium is planned tentatively to be held in Montpellier, France, sometime during April, 1962. Summaries of papers proposed for presentation should not exceed 300 words and should be submitted to the organizer, Dr. F. E. Echardt, Botanical Institute, Montpellier, France, on or before December 1; preferably they should be written in English or French.

This symposium is planned to meet the needs for a standardization of ecological measuring techniques, as expressed by the UNESCO General Symposium on Arid Zone Problems held at Paris in 1960.

• **World-Wide Installation of Standard Seismic Equipment**—Installation of modern seismographic equipment at 125 earthquake recording stations in 65 countries and islands was started in mid-1961 and is scheduled for completion in late 1962. Technicians of the Coast and Geodetic Survey, with financial support of the Advanced Research Projects Agency (ARPA) of the Department of Defense will install the instruments. The object of this program, part of the *Vela-Uniform* project of ARPA, is to provide sensitive standardized instruments for the quantitative study of earthquakes, earthquake mechanisms, seismic wave propagation, and energy. The equipment, having a value of approximately $2,000,000, is being supplied by The Geotechnical Corporation of Garland, Texas.

• **Antarctic Programs Office Established by NSF**—The National Science Foundation has announced the establishment of an Office of Antarctic Research Programs, formerly a part of the Special International Programs. Thomas O. Jones has been appointed Head, and Albert P. Crary Chief Scientist. The new office has responsibility for the United States Antarctic Research Program, which includes all U. S. scientific work carried out in Antarctica, and involves scientists from colleges and universities, and government agencies. Research is carried out in biology, geodesy and cartography, geology, glaciology, meteorology, oceanography, upper atmosphere physics, and seismology.

• **Memorial Lectureship in Geology Established at M.I.T.**—A memorial lectureship in geology in honor of William Otis Crosby, a graduate of the class of 1878, and one of the earliest and foremost economic and engineering geologists of his day, has been established at Massachusetts Institute of Technology under a bequest from the estate of his son, the late Irving B. Crosby, who for many years was a consulting engineering geologist in Boston, Mass. Under the terms of the bequest geologists of note will be brought to the Institute to give courses of lectures on some aspect of the science.

The first course will be offered during two terms of the academic year 1961-62, by Joseph L. Gillson, recently retired as Chief Geologist of the E. I. Dupont de Nemours Company, Wilmington, Delaware, and will be in the field of industrial minerals.

• **New Journal for Infrared Physics**—The first number of a new research journal, *Infrared Physics*, was issued as of March 1961. The journal is established as an international forum for the publication of scientific papers in the field of infrared physics and its applications, and is concerned with theory, experiment, and instrumentation as applied to infrared detection and transmission, and to problems of atmospheric, meteorological, geophysical, astrophysical, and space research. It is published by Pergamon Press Limited, Headington Hill Hall, Oxford, England (Pergamon Press, Inc., 122 East 55th St., New York 22). Subscriptions are $10.00 for individuals, and $20.00 for institutions and libraries. The first issue contains 10 leading articles totalling 103 pages.

• **English Abstracts of Russian and Chinese Journals Published Serially**—Beginning in February 1961 the U.S. Department of Commerce, Office of Technical Services is publishing a series of pamphlets, *English Abstracts of Selected Articles from Soviet Bloc and Mainland China Tech-*

nical Journals. The pamphlets appear monthly, by series; Series I contains abstracts for the fields of physics, geophysics, astrophysics, astronomy, astronautics, and applied mathematics. Series VI includes meteorology and oceanography. The cost is $9.00 for 6 issues of a series.

- RV CHAIN RETURNS FROM ATLANTIC EQUATORIAL CRUISE—The Research Vessel *Chain*, of the Woods Hole Oceanographic Institution fleet, returned to home port on May 17, after a cruise of three and a half months in the Atlantic equatorial belt. A bathymetric survey of the area was made from the equator to about 4 degrees south latitude, and from the Romanche Trench to 10 degrees west. The survey indicated that the Trench is not open at both ends, permitting the passage of bottom water. However, a long narrow cut in the mid-Atlantic ridge, to a depth of about 200 fathoms, was located approximately 200 miles to the east, and a hydrographic survey later confirmed that cold water from the south crosses the ridge in this cut.

- ANTARCTIC RESEARCH SHIP WILL BE FLOATING LABORATORY—The USNS *Eltanin* is being modified and equipped as a sea-going scientific laboratory for the U. S. Antarctic Research Program. An agreement between the National Science Foundation, which administers the research program, and the Military Sea Transportation Service (MSTS), which owns and operates the ship, provided for conversion of the cargo vessel during the summer and fall, 1961. The cost will be borne principally by NSF, which will be responsible for the scientific program. The ship will continue to be owned and operated by MSTS. It is expected that the ship will work in Antarctic waters at least 10 months a year, with individual cruises varying from one to several months. The ship is 266 feet long, has a 51-foot beam, and draws about 19 feet.

- STANFORD TO HAVE WORLD'S LARGEST SCIENTIFIC SAILING VESSEL—Under a grant awarded by the National Science Foundation, the Hopkins Marine Station of Stanford University will convert a two-masted schooner into the largest sailing ship in the world to be used for scientific purposes. The steel-hulled, 172-foot schooner is the gift of George Vanderbilt. The vessel will be used on a year-around schedule of research and graduate training in biological oceanography.

- OPERATION 'DEEP FREEZE 61' COMPLETED—The U. S. Navy Hydrographic Office has issued a brief preliminary report on 'Operation Deep Freeze 61' a marine geophysical program conducted in the Antarctic during the austral summer of 1960–61. Oceanographic, geomagnetic, geologic, geographic and bathymetric studies were made. The preliminary report presents a summary in tabular form; a more complete presentation of the data is being processed for publication. The project was supported by a National Science Foundation grant.

- FOREIGN FIELD GEOGRAPHICAL RESEARCH PROGRAM ANNOUNCED—The National Academy of Sciences-National Research Council has announced its seventh annual program of geographical research, to be conducted in 1962 under the financial sponsorship of the Office of Naval Research. The object of the program is to strengthen American geography by stimulating greater participation in field research outside of the English-speaking areas of North America. The program is designed primarily for graduate students who are now working for doctorates, but recipients of the doctorate within the last few years are also eligible. Financial assistance will vary according to needs; it is usually adequate for travel, and field and living expenses. Projects of at least six months duration are preferred.

Applications for projects to be started before April 1, 1963 must be submitted before December 1, 1961. Requests for further information should be addressed to Foreign Field Research Program, Division of Earth Sciences, 2101 Constitution Ave., Washington 25, D. C.

- CLOSING DATE FOR NSF FELLOWSHIPS—The closing date for receipt of applications by the National Science Foundation for its Science Faculty and Senior Postdoctoral Fellowships, for awards to be made on December 11, 1961, is October 9. Applications including plans of study, affidavit and loyalty oath should be sent to Fellowships Section, Division of Scientific Personnel and Education, National Science Foundation, Washington 25, D. C.

- AWARDS UNDER THE FULBRIGHT ACT—The Department of State and the Board of Foreign Scholarships have announced the availability of awards for University Lectureships and Advanced Research in 26 countries for 1962–1963, under the Fulbright and Smith-Mundt Acts. Application forms are obtainable from the Conference Board of Associated Research Councils, Committee on International Exchange of Persons, 2101 Constitution Avenue, Washington 25, D. C. The closing date for receipt of applications is October 1, 1961. U. S. citizenship, at least one year of collegiate teaching experience (for lectureship), a doctoral degree (for research grants), and in some cases a knowledge of the language of the host country are eligibility requirements.

- UNIVERSITY OF ARIZONA AWARDED RESEARCH GRANTS—Four research grants totaling $77,111 have been awarded to the new Lunar and Planetary Laboratory of the University of Arizona's Institute of Atmospheric Physics, established in 1960 by Gerard P. Kniper, Professor of Astronomy.

- GRADUATE COURSE ON WATER CYCLE AT COLORADO STATE UNIVERSITY—A one quarter graduate course on *The Atmosphere and the Water Cycle* will be offered for the first time by Colorado State University, Fort Collins, Colorado, during the winter quarter (January to March), 1962. The course is part of the graduate training leading to the Master of Science degree in atmospheric science. Knowledge of meteorology on a general text level is prerequisite. A limited number of undergraduate enrollments will be accepted. For information relating to the course, tuition, and living expenses, write to Prof. Herbert Riehl, who will be in charge of the course.

- **New Department of Geophysical Sciences at Chicago University**—A newly created department of Geophysical Sciences at the University of Chicago will have on its staff all present members of the Departments of Meteorology and Geology, and some member of the Departments of Astronomy and Chemistry and of the Enrico Fermi Institute for Nuclear Studies. Sverre Petterssen, Professor of Meteorology, heads the new department.
- **Advisory Council for Aerospace Research Formed**—Headquarters office of Aerospace Research, U.S. Air Force, has formed an Advisory Council of 22 scientists to furnish technical advice and information to the highest levels of the Department of Defense. The members are drawn from the office of Aerospace Research, its Aeronautical Research Laboratories at Dayton, Ohio, and the Cambridge Research Laboratories (CRL) at Bedford, Mass. Included as members of the new Council are Brigadier-General Benjamin G. Holzman, and Hans Hinterreger of CRL.
- **International Union of Geological Sciences Formed**—A new scientific association, the International Union of Geological Sciences (IUGS), with memberships from 30 countries, has been founded, following a meeting held in March 1961, at UNESCO House, Paris. The Union was proposed by the 21st International Geologic Congress at its Copenhagen meeting in the summer of 1960.
- **TIROS I Pictures of Earth Available to Public**—That the public may obtain pictures of the Earth taken from TIROS I, the World's first experimental weather satellite, has been announced by F. W. Reichelderfer, Chief of the U. S. Weather Bureau. Seven 100-foot reels have been released, and the remaining 48 reels will be available in the near future. Either positive transparencies or duplicate negatives may be purchased at $4.00 per reel. Only orders for complete reels will be accepted. The photographs may be obtained from the National Weather Records Center, Asheville, North Carolina.
- **Exploration Geophysicists to Meet in Denver**—The theme of the 31st Annual Meeting of the Society of Exploration Geophysicists to be held in Denver, November 5-9, 1961, is 'Exploration in a Changing World.' Walter Orr Roberts, Director of the National Center of Atmospheric Research, Boulder, will be the keynote speaker, and it is expected that he will emphasize the contributions and importance of space exploration.
- **Earth Sciences Laboratory Under Construction Near Leonard, Oklahoma**—The Jersey Production Research Company, affiliate of Standard Oil Company (N. J.) and Humble Oil and Refining Company, Tulsa, Oklahoma, is constructing an Earth Sciences Laboratory near Leonard, Oklahoma, for the study and measurement of processes and phenomena that occur in the Earth's crust.
- **Well-Known Science Publishing Houses Merge**—John Wiley and Sons, Inc., and Interscience Publishers, Inc., both of New York, and well-known as publishers of scientific works have announced that they plan to merge, under the name of John Wiley and Sons, Inc. The Interscience imprint will be continued.
- **Rocks Dredged from Wall of Puerto Rico Trench**—A collection of rocks dredged from the north wall of the Puerto Rico trench, which lies under 3 to 4 miles of water about 100 miles north of Puerto Rico, was obtained during a recent cruise of Research Vessel *Chain* of the Woods Hole Oceanographic Institution. The collection includes some that are ultrabasic rocks, believed to be the first specimens ever obtained from the layer of the Earth's crust that lies just above the Moho Discontinuity. In addition, the hauls contained a profusion of sedimentary, igneous, and metamorphic rocks that have become exposed as a result of gigantic fractures of the Earth's crust, and downward movement of crustal blocks to form the trench.

Personalia

- **Albert V. Baez**, Associate Professor of Physics at Harvey Mudd College, Claremont, California, has been appointed Chief of Division of the Teaching of Basic Sciences in the Department of Natural Sciences, UNESCO, Place de Fontenoy, Paris, France, for a period of two years beginning July 1, 1961.
- **Robert B. Banks**, Assistant Dean of Research and Professor of Engineering Science at Northwestern University, Evanston, Illinois, is in Bangkok, Thailand, on a two-year assignment as Director of Research of the SEATO Graduate School of Engineering.
- **Virgil E. Barnes**, Professor of Geology at the University of Texas, has returned from a seven-month leave of absence, during which he made a field study of tektite localities and meteorite craters in Europe, Asia, Australia, and Africa.
- **Ari Ben-Menahem** has been appointed a Research Fellow at the California Institute of Technology, Seismological Laboratory.
- **Henry Bryant Bigelow**, Research Oceanographer at Harvard University received the oceanographic medal named in his honor on March 16 at a special ceremony held at the Harvard Faculty Club.
- **Lewis M. Branscomb**, Chief of the Atomic Physics Division at the National Bureau of Standards, has been awarded the U. S. Department of Commerce Gold Medal for Exceptional Service in recognition of his contributions in the '. . . development of basic knowledge of the atomic proc-

esses of stellar atmospheres, the terrestrial ionosphere, and interplanetary space'.

- **Keith E. Bullen**, Professor of Applied Mathematics at the University of Sydney, Australia, and William Bowie Medalist for 1961, has been elected a foreign associate of the National Academy of Sciences.

- **Johannes M. Burgers**, of the Institute for Fluid Dynamics and Mathematics at the University of Maryland was awarded the Modesto Panetti prize and gold medal of the Accademia delle Scienze di Torino at Turin, Italy, on May 10, 1961, in recognition of his work in applied mechanics. On May 12 he gave a lecture at the Politecnico in Turin.

- **P. Edward Byerly**, formerly with the Geophysics Branch of the United States Geological Survey, is now a research geophysicist at La Habra Laboratories of California Research Corporation, San Francisco.

- **Preston E. Cloud, Jr.**, has resigned from the U. S. Geological Survey and is now Professor of Geology at the University of Minnesota.

- **Edward U. Condon**, Professor of Physics and head of the Department of Physics at Washington University, has been appointed Chairman of the Editorial Board of the new magazine, *International Science and Technology*, which will start publication in January, 1962.

- **Arthur S. Cosler, Jr.**, recently Director of the Intelligence Systems Division of Broadview Research Corporation, has been appointed Vice President for Research and Development, Geonautics, Inc., Washington, D. C.

- **Karl F. Dallmus**, Geological Engineer of Caracas, Venezuela, has received the Distinguished Achievement Award of the Colorado School of Mines, of which he is a graduate.

- **James L. Dyson**, Head of the Department of Geology at Lafayette College, has been elected President of the Pennsylvania Academy of Science for 1961–62.

- **Maurice Ewing**, Director of Lamont Geological Observatory, has received the Priestley Memorial Award from Dickinson College, in recognition of his research in oceanography and Earth sciences.

- **Herbert Friedman** of the Naval Research Laboratory, Washington, D. C., has been appointed part-time Professor of Physics at the University of Maryland.

- **Albert S. Fry**, recently Chief of the Hydraulic Data Branch of the Tennessee Valley Authority, retired from that agency on June 30, and is now practicing as a consulting engineer.

- **Rufino Gea**, formerly with Geoprosco of Madrid, Spain, has joined the staff of Aero Service (Bahamas) as Manager of its Ground Geophysics Department.

- **Francis R. Hall**, formerly with the Stanford Research Institute at Menlo Park, California, is now Associate Hydrologist and Faculty Associate at the New Mexico Institute of Mining and Technology, Research and Development Division, Socorro, New Mexico.

- **Donald R. F. Harleman**, Associate Professor of Hydraulics at Massachusetts Institute of Technology, was awarded a Research Prize by the American Society of Civil Engineers at the Phoenix Convention of the Society.

- **Bruce C. Heazen**, Assistant Professor of Geology at Columbia University and staff member of Lamont Geological Observatory, lectured in Russia during June as an official guest of the USSR Academy of Sciences.

- **Harry H. Hess**, Chairman of the Department of Geology at Princeton University, and Captain USNR, has been selected from the Research Program for promotion to the rank of Rear Admiral.

- **Hans E. Hinterregger**, physicist at Air Force Cambridge Research Laboratories, has received the Air Force Meritorious Civilian Award for his work in ultraviolet radiation research.

- **Woodrow C. Jacobs** has left the Legislative Reference Section of the Library of Congress and is now Director of the Oceanographic Data Center of the U. S. Navy Hydrographic Office.

- **Don Kirkham** of the Department of Agriculture at Iowa State University was one of ten panelists, from seven countries, on the use of radioisotopes in agriculture, at a meeting held on May 15–19 at Vienna, Austria, by the International Atomic Energy Agency.

- **John A. Knauss**, of the Scripps Institution of Oceanography, has been appointed Dean of the newly established graduate school of oceanography at the University of Rhode Island.

- **Carl L. Kober**, recently a Vice President of the Arco Corporation, has been appointed Director of Advanced Programs for The Martin Company's Denver Division.

- **Thomas A. Manhart**, Chairman of the Board, Century Geophysical Corporation, has received the Distinguished Achievement Award of his *alma mater*, the Colorado School of Mines.

- **George A. Marston**, Dean of Engineering at the University of Massachusetts, has been elected a Vice President of the American Society for Engineering Education.

- **Gerald T. McCarthy**, of the firm of Tippets-Abbett-McCarthy-Stratton, has been elected President of the American Institute of Consulting Engineers.

- **Samuel B. Morris**, Consulting Engineer to the Los Angeles Department of Water and Power, and former Dean of the Engineering School of Stanford University, has been elected to honorary membership in the American Society of Civil Engineers.

- **Robert G. Paquette**, formerly Research Associate Professor of Oceanography at the University of Washington, has joined the staff of the Defense Systems Division, of General Motors Corporation at Santa Barbara, California. He will continue to specialize in instrumental aspects of oceanography.

- **Richard L. Pfeffer** of the Lamont Geological

Observatory, Columbia University, has been appointed Chairman of the Oceanography and Meteorology Section of the New York Academy of Sciences, for 1962.

• **Robert A. Phinney** of the Seismological Laboratory, California Institute of Technology, has been appointed Assistant Professor of Geophysics at that institution.

• **Frank Press**, Professor of Geophysics at the California Institute of Technology, has been named 'California Scientist of The Year' by the California Museum of Science and Industry Foundation, and received a prize award of $5000.

• **Kalpathi R. Ramanathan**, meteorologist with the Physical Research Laboratory at Ahmedabad, India, has been awarded the International Meteorological Organization prize of the World Meteorological Organization.

• **Roger Revelle**, Dean of the School of Science and Engineering of the University of California at San Diego, and Director of the Scripps Institution of Oceanography, has been named a member of the Advisory Council of the Peace Corps, by President Kennedy.

• **M. David Rostoker**, formerly of the staff of Quincy Junior College, Quincy, Massachusetts, is now with the Research and Development Division of Arthur D. Little, Inc., Cambridge, Mass.

• **Thorndike Saville**, Dean Emeritus of the College of Engineering of New York University, and an international authority on hydrology and coastal engineering, has been elected to honorary membership in the American Society of Civil Engineers.

• **Allen H. Schooley**, Associate Director of Research for Electronics at the U. S. Naval Research Laboratory, Washington, D. C., participated in a study of oceanographic problems at Scripps Institution of Oceanography during the summer.

• **John Schwab**, of the Defense System Division, General Motors Corporation, Detroit, represented the AGU at the inauguration of James W. Miller as President of Western Michigan University, on May 20.

• **Stewart W. Smith**, of the Seismological Laboratory, California Institute of Technology, has been appointed Assistant Professor of Geophysics at that institution.

• **David K. Todd**, Associate Professor of Civil Engineering at the University of California (Berkeley), received a Research Prize of the American Society of Civil Engineers at the Phoenix, Arizona, convention of the Society.

• **C. H. M. Van Bavel** of the University of Arizona, Cotton Research Station, was a member of the panel of ten scientists dealing with the use of radioisotopes in agriculture, at a meeting held by the International Atomic Energy Agency at Vienna, Austria, on May 15–19.

• **Theodore von Karman** of Pasadena, California, one of the world's leading aeronautical engineers, former member of the Air Force Scientific Advisory Board, and once Chairman of the NATO Advisory Group for Aeronautical Research and Development, has received an honorary Doctor of Science degree from Brown University. He was also honored on May 11, in Washington, D. C. by a banquet, and a lecture on the Karman Vortex Street in magnetofluiddynamics, in recognition of his 80th birthday; the lecture was delivered by Adolf Buseman of NASA.

• **Fred Lawrence Whipple**, internationally known astronomer of the Smithsonian Astrophysical Observatory at Cambridge, Massachusetts, has been awarded the honorary degree of Doctor of Letters, by Northeastern University.

• **Basil W. Wilson**, formerly Professor of Engineering Oceanography at Texas A and M College, is now with the National Engineering Science Company, Pasadena, California.

• **Abel Wolman**, Professor of Sanitary Engineering at the Johns Hopkins University, has been elected to honorary membership in the American Society of Civil Engineers, in recognition of his leadership in his field.

• **Robert Cameron Colwell**, Professor Emeritus of Physics, West Virginia University, died at Morgantown, West Virginia on June 10, 1959. He was born in Fredericton, New Brunswick, October 14, 1883. He took his undergraduate and early graduate academic work at the University of New Brunswick, where he received a B.A. degree in 1904. He attended Harvard University and the University of Chicago, for selected courses in Physics, and in 1918 obtained a Ph.D. degree in Physics from Princeton University. In 1947 he received an Honorary Doctor of Science degree from Geneva College, where he had been Professor of Physics from 1907 to 1922. He became Professor of Physics, and Head of the Department at West Virginia University, in 1924, from which position he retired in 1954 with the title of Professor Emeritus. He continued to be active in research, however, until his death in 1959. He was author of more than 150 publications in the field of physics, particularly in the areas of relativity, wave propagation, reflections of radio waves in the troposphere, and meteorology. He joined the AGU in 1949.

• **Lindsay P. Disney**, Assistant Chief of the Marine Data Division of the U. S. Coast and Geodetic Survey, died at his home in Arlington, Virginia, on May 23, 1961. He was born in Baltimore, Maryland August 16, 1895. He graduated from George Washington University in 1924 with a degree in Civil Engineering, while serving as a mathematician with the Coast and Geodetic Survey, which he had joined in 1916. His principal field of interest was oceanography, especially tides and currents. He made many noteworthy contributions on tides, currents, and related subjects, prepared the first tidal current charts published by the Survey, and was compiler of tidal current charts for several important American harbors. He joined the AGU in 1934, was a former Secretary of the Section of Oceanography, and had served on various committees.

• **Herbert Grove Dorsey**, formerly Chief of the Research Section of the U.S. Coast and Geodetic Survey, died on June 24, at his home in Washington, D. C. He was 85 years old. He was born in Granville, Ohio, was educated in the local schools, and obtained Bachelor and Master degrees at Denison University, majoring in physics and electrical engineering. He obtained a doctorate at Cornell University. He moved to Washington, D. C. in 1926, when he joined the Coast and Geodetic Survey.

Dr. Dorsey was a distinguished scientist and inventor, and made significant contributions in the fields of radio, telephony, and oceanography. Particularly important was his invention for submarine use that permitted measurement, by radio, of ocean-floor topography, and consequently made it possible for vessels to avoid hazardous undersea projections.

He had been a member of AGU for more than twenty years until his retirement in 1952.

• **Hugh Richard Gault**, Professor of Geology and Head of the Department of Geology at Lehigh University, died on July 5, 1961, at Bethlehem, Pennsylvania. He was born in Chicago, Illinois, on February 7, 1915. He obtained an A.B. degree in geology at DePauw University in 1936, an M.A. at the University of Missouri in 1938, and a Ph.D. at The Johns Hopkins University in 1942. In 1942 he joined the U.S. Geological Survey, and was assigned to the Alaska Branch, studying ore deposits in southern Alaska. He left the Geological Survey at the close of World War II, in 1946, to accept a position as Assistant Professor of Geology at Lehigh University; he became Professor of Geology in 1952 and Head of the Department of Geology in 1959. In 1953–54 he served as Executive Secretary of the Division of Earth Sciences, National Research Council, in Washington, D. C. His special interests and publications were in the fields of economic geology, the geochemistry of limestone, and the synthesis of sulfides. He joined the AGU in 1944, and was elected Secretary of the Section of Tectonophysics in 1959.

• **Benjamin Earl Jones**, formerly Chief of the Water and Power Branch, Conservation Division, the U.S. Geological Survey, died in Washington, D. C., on July 3, 1961. He was born in Conneaut, Ohio, January 11, 1883. After graduation from the University of Michigan in 1908 as a civil engineer he worked for the Federal Government as a highway engineer until 1913, when he transferred to the Geological Survey. Through his work in preparing estimates of water power of the world, at the time of the Versailles Peace Conference in 1919, and his maintenance of such estimates until he retired in 1953, he became one of the world's foremost authorities in that field. In particular, from 1921 until his retirement he made all the revisions in the estimate of potential water power in the United States. In 1932 he made the first of the Geological Survey's geophysical studies of potential dam sites in the United States. Upon his retirement the Department of the Interior awarded him its Distinguished Service Award. He joined the AGU in 1933 and became a life member in 1954.

• **Alfred Loehnberg**, Technical Advisor to the United Nations Headquarters in New York, died in New York City on May 13. He was born in Epe, Germany August 30, 1908, was educated in Germany, Austria, and England, and obtained a doctorate at Goettingen University in 1932. He took up residence in Israel in 1933, where he was a consulting hydrologist and geophysicist, serving at various times as consultant to the Governments of Israel, Transjordan, and Cyprus, and to the Allied Forces of the Middle East during World War II. He carried on scientific studies on groundwater in semiarid countries. From 1957 to 1959 he was head of the Groundwater Department at the Institute of Applied Science, University of Mexico, under the technical assistance program of UNESCO. From December 1960 he was a technical advisor on groundwater matters to the United Nations at New York. He was author of many papers and reports on geo-electrical prospecting, groundwater development, water supply and economics, mineral and oil exploration, and geothermal energy. He joined the AGU in 1958.

• **Pierre Molard**, meteorologist and seismologist at the Observatory, Morne des Cadets, Fond St. Denis, Martinique, died on March 24, 1959. He was born June 21, 1911 at Issy-L'Eveque (Saône-et-Loire), France. Although educated at the University of Paris as a Mining Engineer, he entered public service in 1935 as a meteorologist in the Office of Colonial Meteorology, Paris. In 1936 he was assigned to the Martinique Observatory at Fort-de-France and placed in charge of the volcanological station at Morne-des-Cadets, located seven kilometers from Mount Pelée, where he took up residence to make continued seismological observations of that volcano; here he installed the great 20-ton seismograph of Quervain-Piccard. When Martinique became a *departemente* of France in 1947, Molard was made Director of the Martinique Observatory, which, at his request, became attached to the Institut de Physique de Paris. Later he established another seismological station on Guadaloupe, near the volcano Soufrière.

Beginning in 1940, Molard dedicated himself particularly to a program of highly productive research in meteorology and seismology, especially as related to the regional volcanism. Probably his most important experimental work in this program was in connection with the adaptation of electronic amplification to seismographs; another fruitful area of research was in the study of T-waves that he discovered in the seismic recordings, and upon which subject he has written numerous papers, in part in collaboration with J. Coulomb. He had been a member of AGU since 1952.

Union, Section, and Committee Activities

Minutes of the Council Meeting, American Geophysical Union

April 22, 1961

The first meeting of the new Council was called to order at 09h 00m in the Board Room of the National Academy of Sciences, 2101 Constitution Avenue, Washington 25, D. C., by President Lloyd V. Berkner. Council members present: L. R. Alldredge, L. V. Berkner, Edward B. Espenshade, Jr., Willis B. Foster, James Gilluly (for Thomas B. Nolan), Harry H. Hess, Woodrow Jacobs, J. W. Joyce, Walter B. Langbein, Thomas F. Malone, Leonard M. Murphy, A. O. C. Nier, Donald Pritchard, F. W. Reichelderfer, A. Nelson Sayre, André C. Simonpietri (for H. P. Robertson), L. B. Slichter, Waldo E. Smith, and C. A. Whitten. Also present were Philip H. Abelson, Iris Y. P. Borg, Linn Hoover, Helmut E. Landsberg, Gordon J. F. MacDonald, Arthur E. Maxwell, J. Hugh Nelson, Morris Neiburger, James A. Peoples, Jr., Louis O. Quam, Ethel G. Sanders, Alan H. Shapley, Ralph N. Wilson, David R. Wones, George P. Woollard, and Hattan S. Yoder, Jr.

The Executive Committee of the Council held a meeting on March 25, 1961, to complete action on matters appropriately cited in the minutes, and to make recommendations to the Council on policy matters, which must be brought before the Council.

A motion was made and approved that

> The minutes of the Executive Committee should be accepted in principle.

Matters referred to the Council by the Executive Committee were brought up for subsequent action and are reported below.

With regard to cover-to-cover publication of Russian journals, on which action was taken by the Executive Committee on March 25 to the effect that full journal translation should include everything, it was agreed that

> Some administrative discretion should be exercised with regard to the publication of articles that contain no scientific or technical information.

On recommendations of the Executive Committee relating to the delegation of responsibility and authority, the relationship of the Executive Committee to the Council, and the control of funds, and upon motions duly made and seconded, the Council unanimously adopted the following three resolutions:

(1). *Delegation of Authority to the Executive Committee.* As specified in By Law 3, the Executive Committee of the Council shall "execute the affairs of the Union between meetings of the Council and in accord with its policy decisions." The Council of the AGU, by this resolution, specifically delegates to the Executive Committee of the Council authority and responsibility for all activities of the AGU, within the policy decisions of the Council, but specifically reserving for its own decision all major matters relating to policy, the approval of the budget, and major changes in the budget. The minutes of the Executive Committee shall be circulated to the Council not less than fourteen days in advance of the meeting. The Council reserves the right to review the minutes and all actions of the Executive Committee of the Council, and to accept or revise these as the Council deems appropriate.

(2). *Delegation of Authority to the General Secretary.* As specified in By Law 19, the General Secretary is responsible for the general administration of the Union activities as determined by the Council, shall exercise general supervision over the Executive Secretary, and, serving as Treasurer, shall receive and disburse funds in accordance with the instructions of the Council. Specifically, the Executive Committee delegates to the General Secretary responsibility for the issuance to the Executive Committee of regular financial reports and for making adjustments of those salaries below $10,000 per annum, within budgetary limitations. Reports received on all matters relating to policy, both minor and major, must be referred to the Executive Committee.

(3). *Control of Funds.* The General Secretary is to bring immediately to the attention of the Executive Committee any anticipated over-expenditures on any major budget items that appear to exceed the approved budget by more than five per cent.

Report of the General Secretary

(The report of the General Secretary prepared as of March 13 for the Executive Committee Meeting on March 25 follows.)

The report of the General Secretary for the Executive Committee meeting of October 22, 1960, was recorded in the minutes and published in the March 1961 issue of the *Transactions*, pages 63-68.

Approval of Minutes—The minutes of the Executive Committee meeting of October 22, 1960, were circulated to the Committee and approved by mail ballot, and published in the *Transactions* of March 1961, pages 63-97.

Changes in Statutes and By Laws, and the Establishment of the Council—Based on the action taken by the Executive Committee at the regular meeting in April 1960 and its action at the Helsinki meeting on July 27, 1960, proposed changes in the Statutes were laid before the membership for mail ballot and before the Governing Board of the National Academy of Sciences in August and September of 1960. An overwhelming vote of the membership (see March 1961 Transactions, page 76) favored all proposals. Also, the Governing Board of the Academy gave its approval, and the related changes in the Statutes received final approving action at the October 22 meeting. Accordingly, the new governing board of the AGU, now referred to as the Council, was effective as of January 1, 1961, and was constituted as follows:

President, Lloyd V. Berkner
Vice President, Thomas F. Malone
General Secretary, A. Nelson Sayre
Retiring President, Maurice Ewing
Secretary for International Participation, J. Wallace Joyce
Section of Geodesy, Charles Pierce, President
Section of Seismology, L. M. Murphy, President
Section of Meteorology, Woodrow C. Jacobs, representative for President Thomas F. Malone
Section of Geomagnetism and Aeronomy, Leroy R. Alldredge, President
Section of Oceanography, Donald W. Pritchard, representative for President Walter H. Munk
Section of Volcanology, Geochemistry, and Petrology, Alfred O. C. Nier, President
Section of Hydrology, Walter B. Langbein, President
Section of Tectonophysics, Patrick M. Hurley, President
Representatives from government agencies:
  Department of Defense, Willis B. Foster
  Department of the Interior, Thomas B. Nolan
  Department of Commerce, F. W. Reichelderfer
  National Science Foundation, John Lyman
President of the National Academy of Sciences, D. W. Bronk
Foreign Secretary of the National Academy of Sciences, H. P. Robertson
Chairman of the Section of Geophysics of the National Academy of Sciences, L. B. Slichter
Chairman of the Division of Earth Sciences of the National Research Council, Edward B. Espenshade, Jr.
Three members at large nominated by the Section of Geophysics of the National Academy of Sciences, as follows:
  Harry Hess
  Walter H. Munk
  E. H. Vestine
Officers of the International Union of Geodesy and Geophysics who are citizens and residents of the United States:
  Joseph Kaplan, Vice President, IUGG
  K. Hilding Beij, Member, Finance Committee, IUGG
  Charles A. Whitten, President, Association of Geodesy
  W. D. Lambert, Honorary President, Association of Geodesy
  Perry Byerly, President, Association of Seismology and Physics of the Earth's Interior
  Horace R. Byers, President, Association of Meteorology and Atmospheric Physics
  Gordon A. Macdonald, Vice President, Association of Volcanology
  H. G. Wilm, Honorary President, Association of Hydrology

The Executive Secretary shall serve as Secretary of the Council with voice but without vote, Waldo E. Smith

In accordance with the revised Statutes and By Laws, steps were taken to establish the Executive Committee of the Council, of which this March 25 meeting was the first meeting. Ex-officio members include the President, the Vice President, the General Secretary, and the Secretary for International Participation. Members elected by the Council (by mail ballot) are as follows: F. W. Reichelderfer, Maurice Ewing, Joseph Kaplan, Walter B. Langbein, and Charles A. Whitten.

Actions of the Executive Committee and of the Council, by mail ballot—The actions taken by mail ballot since the last meeting of the Executive Committee are shown in the table on page 330.

Publications—The *Journal of Geophysical Research* (*JGR*) has gone forward each month. The March issue has been returned to the printer in page proof, and will probably be released in advance of the meeting to be held March 25. The April issue is well advanced. Both of these issues will be of average size. We have received the $15,000 grant from the National Science Foundation for assistance in publishing the Journal during 1961 and, as will be seen in the accompanying financial statement, by allotting half the dues and all of the *JGR* subscription money to the Journal, a satisfactory financial situation is attained, the fund showing an increase of about $4,500 in the first two months of this year (using

Date	Subject	Approve	Disapprove
Executive Committee: 1960			
Oct. 19	Proposed Corporation Member: Western Geophysical Company of America	39	0
Nov. 14	Sixth List of proposed new members (51 members and 23 students)	36	0
Nov. 18	Proposed Corporation Member: Varian Associates	37	0
Dec. 10	Minutes of the Executive Committee meeting of October 22	23	0
Dec. 20	Seventh List of proposed new members (53 members and 12 students)	35	0
Dec. 23	Special ballot on proposed membership of one applicant	0	40
Council: 1961			
Jan. 6	Proposed Corporation Member: Pure Oil Company	22	0
Jan. 13	Proposed Corporation Members: Richfield Oil Corp., and Sandia Corporation	22	0
Jan. 18	Proposed Corporation Member: Travelers Research Center, Inc.	27	0 (1 abstained)
Jan. 19	First List of proposed new members (65 members and 9 students)	28	0
Jan. 25	Ballot on Members at Large of Executive Committee of the Council	25 ballots cast	
Jan. 30	Proposed Corporation Members: Douglas Aircraft Co., Inc., and Analytic Services, Inc.	28	0
Feb. 10	Proposed Corporation Members: Martin Company and United Aircraft Corp.	27	0
Feb. 13	Second List of proposed new members (65 members and 31 students)	24	0
Feb. 24	Proposed Corporation Member: Arthur D. Little, Inc.	22	0
Mar. 2	Proposed Corporation Member: Chance Vought Corporation	20	0
Mar. 13	Proposed Corporation Member: AGA Corporation of America	27	0 (1 abstained)

pro-rata allocation of anticipated dues receipts, subscriptions, and grant funds).

At the meeting on October 22, the recommendation was made that we apply to the National Science Foundation for a grant to pay page charges of solicited foreign papers, in order to eliminate the possible present inhibition on the part of foreign authors to publish in *JGR*. The Executive Committee indicated that it would perhaps be more appropriate to approach the National Science Foundation to determine if current grant funds might be used for the payment of page charges for foreign authors; accordingly, such action was approved. To my knowledge, this has not yet been done, although the Executive Secretary has had informal conversations with members of the National Science Foundation as a preliminary to such formal discussions.

A summary of the issues of *JGR* from October 1960 through March 1961, and of the Transactions for December 1960 and March 1961 is shown in the table at right.

Issue	Text pages	Unnumbered pages	Pages of paid advertising	Edition
Journal of Geophysical Research				
Oct. 1960	490	14	6½	9,500
Nov. 1960	344	16	8½	9,500
Dec. 1960	390	10	6½	9,500
Jan. 1961	342	10	7½	10,100
Feb. 1961	322	6	3½	10,100
Mar. 1961	330	14	10	9,500
Transactions				
Dec. 1960	195	12	2	9,200
Mar. 1961	146	6	2½	9,200

The December 1960 number of the *Transactions* contained about 120 pages that comprised a report of the Helsinki meeting of the IUGG. It was anticipated that the National Science Foundation would support this report by a grant, and informal conversations indicated that a grant application would be considered favorably. However, on March 8, 1961, the grant in the amount of $4,807 was disapproved on the grounds that the report had already been published. Actually, the application was dated Oct. 31, 1960, over two months before publication. Because of this, the budget for the *Transactions* for the twelve-month period July 1, 1960, to June 30, 1961, shows a substantial deficit, and the preliminary estimates show that out of the $8,000 budgeted for the *Transactions* in the twelve-month period beginning July 1, 1960, almost $7,000 was expended.

The *IGY Bulletins* continue as hitherto, and three numbers are assembled and included in each quarterly *Transactions*.

The translation and publication of the English edition of *Izvestiya*, Academy of Sciences, USSR, Geophysics Series, is moving along rapidly. Number 8 of 1960 was released on March 6, and all the numbers of 1960 have been translated excepting No. 12, which is scheduled for transmission to the printer on the 20th of March. The project is on schedule. Number 12 is due to be released May 3. The grant funds for the support of the 1960 series have come in, and we have received approval of the grant for the 1961 series and a payment of $15,000 as the first installment on the grant. Number 1 of the 1961 series is in the hands of the translators.

Sales have been somewhat greater than was anticipated, it may be necessary to increase the edition, now 500, for the 1961 series. The present distribution of the 1960 series is 405, including the gratis copies to the members of the Translation Board, the National Science Foundation, abstracting groups, etc.

The Russian Translation Board met on February 27, 1961, to go over translation problems, and expressed satisfaction with the way the *Izvestiya* project is moving along, with a time lag from receipt of the Russian copies to publication of the English edition of about four months. Although the distribution seems to be quite small, the publication seems to reach strategic locations, and is receiving wide use and generally satisfactory acclaim by the users.

A grant of about $25,000 has been received to support translation and publication of an English edition of *Geodesy and Cartography*, 1959 series, in accordance with the recommendations of the Section of Geodesy and the approval of the Executive Committee. The first six numbers have been released, and some disappointment has been expressed at the scientific quality of the material that this journal contains. The 1959 series will be translated in full and published according to the original plan, excepting that papers that are essentially propaganda will be screened out. With regard to the 1960 series, the grant funds have been approved by the National Science Foundation, and in reviewing this matter recently, the Executive Committee of the Section of Geodesy indicated that it feels that the cover-to-cover translation and publication (excepting for the purely propaganda articles) have sufficient merit and importance in the technical aspects of photogrammetry and cartography to warrant full translation, and suggests that it may be appropriate for the Society of Photogrammetry and the American Congress of Surveying and Mapping to extend inactive sponsorship.

The publication of the English edition of *Trudy* 37–40 inclusive of the Geophysical Institute of Moscow has been completed, and it appears that the project will pay a substantial part of the cost. This grant fund will be renegotiated with the National Science Foundation in due course. However, the Board, noting that this particular *Trudy* series has been terminated and has been replaced by two other series, one issued by the Institute of the Physics of the Earth and the other by the Institute of the Physics of the Atmosphere, and noting further that there are many other books in geophysics that should be considered for publication in an English edition, recommended that we undertake the translation and publication of about 2,000 Russian pages a year. A subcommittee has been appointed to select books worthy of such translation. Approval will be sought for an application to the National Science Foundation for a grant in the amount of about $50,000 to finance this series.

Also, the Russian Translation Board had before it a recommendation of the Section of Oceanography to publish an English edition of the *Trudy* of the Marine Hydrophysical Institute and the Marine Sciences portions of *Doklady*. This will probably cost about $15,000 and authority will subsequently be requested to proceed with application for a grant for this purpose.

A year ago, the Section of Hydrology recommended that the Russian journal, *Meteorology and Hydrology*, be issued as a cover-to-cover translation. The Russian Translation Board and the Executive Committee approved this recommendation, but subsequently certain questions were raised. The Section of Hydrology has reviewed its recommendation and recommended the withdrawal of the earlier one, and now it proposes to translate and publish selected papers in hydrology totaling about 750 pages per year, from four to six Russian journals.

The Russian Translation Board accepted this recommendation, and approval will be sought for a grant application of about $23,000 to implement this recommendation.

The Board also reviewed the fact that there are many Russian publications that we can probably obtain on exchange. The representative of the National Science Foundation indicated that it would be willing to consider an application for a grant to cover the cost of subscriptions sent on such exchange, in order to secure scientific literature from Russia, China, and other eastern countries, and to make arrangements for the evaluation of this material. Although the Board took no official action in this matter, it seems appropriate that we might seek a grant, of $5,000 per year, to finance our subscriptions under such exchange, and the related work.

Membership—Membership data as of March 6, 1961, are:

Membership as of September 28, 1960	6118	
Reactivated	6	
New members processed Nov. 14, 1960, to Feb. 13, 1961 (234 regular members, 75 student members)	309	6433
Resigned	149	
Inactive	3	
Deceased (reported since Sept. 28, 1960)	14	166
Total March 6, 1961		6267

Of these, 378 are student members and 101 are life members. In addition, as of this March 13, we have 52 corporation members.

Dues unpaid—As of March 6, 1961, the following dues were unpaid:

For 1961 (154 student members)	1341
For part of 1961 (no student members)	4
For 1960 and 1961 (no student members)	249
For part of 1960 and 1961 (no student members)	4

In addition, 121 persons have not paid their dues in full for 1959. According to the Statutes and By Laws, it is recommended that these be dropped from membership, but with the usual added recommendation that one more effort be made to return them to active membership.

With regard to the distribution, according to Sections, of those who have resigned during this period (149 members), it is noted that most members have more than one affiliation, and accordingly, the 149 members had 327 affiliations. The distribution by Sections of these affiliations is shown in the following table:

Item	Resigned Number	Resigned Per cent	Normal[a] Per cent
Geodesy	28	8.6	8.7
Seismology	36	11.0	12.7
Meteorology	43	13.1	15.2
Geomagnetism and Aeronomy	27	8.3	10.5
Oceanography	41	12.5	10.5
V., G. and P.	36	11.0	8.4
Hydrology	77	23.6	23.0
Tectonophysics	39	11.9	11.0
	327	100.0	100.0

[a] Based on membership as of August 28, 1958.

Deaths—Since the meeting on October 22, 14 deaths have been recorded, as follows: Robert E. Turner, February 27, 1959; Bela Hubbard, November 4, 1959; Johan Van Veen, December 9, 1959; Edgar E. Foster, August 23, 1960; H. H. Finnell, September 7, 1960; Donald M. Baker, October 1, 1960; John T. Lonsdale, October 5, 1960; William I. Hicks, October 20, 1960; Walter R. G. Baker, October 30, 1960; M. R. Huberty, December 12, 1960; Ralph L. Belknap, December 17, 1960; Marvin H. Oleson, January 22, 1961; Frank C. Merriell, January 24, 1961; C. G. Paulsen, January 30, 1961.

Finances—The changeover from the cash basis to the accrual basis was made as of July 1, 1960, and a tentative budget was adopted as a guide at the October 22 meeting (see March 1961 *Transactions*, pages 81–85). At the meeting on October 22, however, the recommendation was also accepted that henceforth the fiscal year should correspond to the calendar year. On the other hand, no budget for the calendar year 1961 is available. It was agreed that the budget adopted October 22 should be used as a guide until the new budget is established, and that henceforth the budget should be prepared for presentation at the fall meeting of the Council for the fiscal year beginning the following January 1. Thus, up to the present we are operating with a budget adopted October 22 as a guide, but a firm budget for the fiscal year (calendar year) in which we are now working will be offered at this meeting. (Editor's note: the budget for the fiscal year ending December 31, 1961, adopted by the Council on April 22, follows the Minutes as Appendix 2.)

Office Staff—The office staff has been reorganized along the lines adopted by the Executive Committee in April, 1960, departmentalizing the work insofar as possible. Mrs. Ethel G. Sanders is Office Manager, and Miss Carol Cameron is secretary to the Executive Secretary. Others operating within this administrative group are Mrs. Judith M. Seek, Mrs. Barbara N. Avery, Mrs. Cynthia L. Beadling, and Miss Iris M. Edgeworth, as full-time staff people, and Mrs. Glenda C. Olmstead, Miss Judith A. Linder, Mr. Timothy O. Temple, and Miss Dinah Snipes, an Antioch College student, as part-time or temporary workers. The bookkeeping and accounting are under the direction of Mrs. Mildred Hards, who has others assigned to her from the above group as the work requires. In the publications group in the office of AGU are Louis W. Currier and Miss Mary Jane Miles, who likewise have others assigned as the workload requires. Mrs. Rowena Peoples is full-time style editor of *Journal of Geophysical Research*, in the Lawrence, Kansas, office; she has the part-time assistance of two students. In the Carnegie Institution of Washington offices we still have the contributed services of CIW editorial staff people, but we are now supplying the services of Nellija O. Doe as a part-time clerk-typist. Mrs. Seek, in the administrative group, might appropriately be designated the membership secretary; she serves as receptionist, opens the mail, and records the membership and certain of the subscriptions. Mrs. Olmstead is a long-time staff member; her services are used largely on special projects and problems that arise from time to time, on which her intimate knowledge of AGU's activities are especially useful. The work continues to be under the direction of the Executive Secretary, Waldo E. Smith.

Quarters—We continue to occupy eight rooms on the third floor of the AAAS building; they are still adequate for our requirements, but are becoming somewhat crowded.

International Matters—We are in a relatively quiescent period in regard to international matters, although plans are simmering, especially with regard to the Thirteenth General Assembly of the IUGG, to be held in Berkeley, California in July and August 1963. Chairman Joyce, Secretary for International Participation, and Chairman Malone of the *ad hoc* committee for the Thirteenth General Assembly will offer reports at this meeting.

Word has been received from the General Secretary of the IUGG that a series of eleven symposia will be held by various associations during the summer months. A list of these appears in the March issue of the *Transactions*. (Editor's note: a revised list was published in the June issue, page 238).

Also, plans are being made by several of the associations for symposia to be held in the United States, preceding the General Assembly. These apparently will be held at various locations on the west coast, including Stanford University and University of California at Los Angeles. Details are not available at this time.

Meetings—Our Forty-Second Annual Meeting will be held in Washington on April 18-21, 1961. The program is complete and was mailed out to participants and to all members about March 10. The program is very heavy again this year; as many as six sessions will be underway simultaneously. For the first time, we will join with the American Meteorological Society in their Annual Banquet, at which the speaker will be Dr. George Kistiakowsky, formerly chief Science Advisor to President Eisenhower, and now Professor at Harvard University.

Through its Planning Committee on Planetary Sciences, AGU arranged a session relating to planetary sciences at the meeting of the AAAS in New York in late December, 1960. The session was attended by about 350 people. In addition, various other programs bearing on geophysics, including the two-day symposium on Chinese science, were co-sponsored by the AGU.

The regional group in the Pacific Southwest held its annual meeting January 26-27; the meeting was attended by about 200 people. The committee for the new triennium has been organized under the Chairmanship of Arthur Pillsbury. Although there will be a Western National Meeting in Los Angeles in 1961, the Regional Committee is proceeding with plans for a regional meeting in Arizona in late January or early February, 1962.

Plans are proceeding for the Western National Meeting, which will be held between Christmas and New Years at the end of 1961. Chairman Kaplan will present a report on this.

Statutes and By Laws—K. Hilding Beij, Chairman of the Committee on Statutes and By Laws, has noted the request for a change in the Preamble to take account of the fact that AGU is not *de facto* the Committee on Geophysics of the National Research Council, such recognition having been informally withdrawn by the NRC about five years ago. This will involve changes in our letterhead, which will be taken into account at the next printing.

It has been suggested also that our Statutes and By Laws have become quite a patchwork of amendments, and we might appropriately recodify them without intent to change. No action, however, has been taken on this matter so far. The appropriateness of recodification might be considered.

Miscellaneous—Steps have been taken to fulfill the various detailed actions taken at the last meeting of the Executive Committee, and to that end, the following committees have been appointed: Committee on Abstracting: James Balsley, Chairman; Committee on Geophysical Data: Woodrow Jacobs, Chairman; Committee on the Upper Mantle: Leonard Murphy, Chairman. In addition, the President has appointed a Committee on Plans for Promotion, under the Chairmanship of Earl Droessler, for the purpose of developing positive plans—instead of an *ad hoc* series of promotion ideas—related to publications and to membership.

Norman H. Ricker represented AGU at the inauguration of the new President of Central State College of Oklahoma on October 23. On November 12, Joe Webb Peoples represented AGU at the Silver Convocation of the University of Connecticut, and on March 11, Lewis W. Douglas represented AGU at the inauguration of Dr. G. Homer Durham as President of Arizona State University. Dr. Thomas F. Malone will represent AGU at the Centennial Convocation of the Massachusetts Institute of Technology on April 9. Richard J. Russell will represent AGU at the inauguration of the new President of Tulane University on April 15. AGU has also received invitations to designate a representative to a symposium on May 11 sponsored by the Air Force Office of Scientific Research in honor of Dr. Theodore Von Karman, on his 80th birthday, and to designate a representative to a general conference on teacher education and professional standards sponsored by the National Education Association at Pennsylvania State University on June 20-23.

Malcolm Rigby represented AGU at, and reported on, a meeting sponsored by the National Science Teachers Association in support of the Future Scientists of America, which explored the possibility and feasibility of contributions from professional societies in support of the Science Achievements Awards program.

An invitation was received from the Senate

Functions Committee of the University of Minnesota to designate a delegate to the inauguration of the new President of the University on February 23, but plans for representation could not be consummated; however, appropriate congratulations and felicitations were sent.

Translation Editor W. S. Jardetzky and the Executive Secretary attended the Endicott House conference on translation problems at Massachusetts Institute of Technology, December 11–12, 1960. On December 13 the Executive Secretary conferred with faculty groups at Harvard University and at MIT on AGU problems. In late December he attended the opening days of the meeting of the AAAS in New York, and visited Chairman T. F. Malone of the *ad hoc* Committee for the Thirteenth General Assembly in Hartford on December 28. In the latter part of January, enroute to the Pacific Southwest Regional Meeting in Berkeley, he visited Dallas, College Station, Houston, and Austin, Texas, conferring with groups with regard to AGU matters. February 6–8 he attended the symposium, *Geodesy in the Space Age*, arranged by the Institute of Geodesy, Photogrammetry, and Cartography of Ohio State University.

A. Nelson Sayre, *General Secretary*

All present stood during the reading of the names of the deceased.

Action on the General Secretary's Report—The report was accepted.

Reports of Committees

Thirteenth General Assembly—Thomas F. Malone, Chairman of the *ad hoc* Committee for the appointment of committees for the Thirteenth General Assembly, noted that three committees will set up the basic structure of the General Assembly. The following recommendation by the Executive Committee was moved and approved:

> There will be three basic committees, namely, the Committee on General Arrangements, which will have general control and responsibility for all activities, the Committee on Finance, and the Committee on Local Arrangements, to make basic preparations for the XIIIth General Assembly of IUGG. L. V. Berkner, as retiring President of AGU, and Joseph Kaplan as Vice President of the IUGG will be made Honorary Chairmen of the General Arrangements Committee. The General Arrangements Committee shall be organized with the Officers of AGU constituting its organizational part; W. W. Atwood, Director of the Office of International Relations, NAS, is also to be included, and others will be named in due course. The Finance Committee will be under the Chairmanship of Joseph Kaplan, who will take steps to nominate and organize the committee for the securing of the necessary funds. The Committee on Local Arrangements will be composed of members in the San Francisco area, including representatives of the University of California and Stanford University. (David Todd of The University of California in Berkeley was subsequently named Chairman, and will also be a member of the General Arrangements Committee.)

The Executive Committee requested Malone and Atwood to consider a tentative budget for the Thirteenth General Assembly, and authorized that this should total approximately $300,000. The following preliminary budget was approved with the understanding that both program and fiscal planning will be under the immediate supervision of the U. S. National Committee for the International Union. (On April 23, the Governing Board of the National Academy of Sciences authorized the acceptance of funds up to $400,000 for the expenses of the General Assembly of the International Union of Geodesy and Geophysics in 1963.)

Travel Subsidy	$100,000
Administration, secretarial, postage	50,000
Printing: announcements, program, abstracts	40,000
Travel and other expenses in raising funds and for committee meetings	20,000
Hospitality	40,000
Contingency	70,000
	$320,000

International Participation—It was noted that word had been received from General Secretary Laclavere of the Internation Union of Geodesy and Geophysics that the Academy of Madagascar is considering the adherence of the Republic of Malagasy to the IUGG but that the category of the Republic had not yet been established. A motion was made and approved that

> The U. S. National Committee approve the adherence of the Republic of Malagasy as a member of IUGG, the category of membership yet to be established.

It was noted that six members are to be appointed by the Council to the Committee on International Participation. The Executive Committee nominated L. V. Berkner, Maurice Ewing, Joseph Kaplan, Walter B. Langbein, Leonard M. Murphy, and Charles A. Whitten for the triennial term of the next administration, which starts July 1, 1961.

A motion was made and approved that

> The nominees presented by the Executive Committee to the Council should be designated to serve for the term of the next administration starting July 1, 1961.

Publications—At the meeting of the Executive Committee on October 22, it was approved that dues for regular members be increased from $10 to $13 beginning January 1, 1962, with the recommendation that rates of subscriptions, dues for student members, and so on, be appropriately adjusted.

Upon recommendation of the Executive Committee of the Council, a motion was made and approved that

> The rates of $25.00 and $5.00, respectively, for subscriptions to the *Journal of Geophysical Research* (*JGR*) and the *Transactions* for 1962 be adopted, that the student membership rate for 1962 should be increased from $4.50 to $5.00, and that the price schedule for back numbers of the *JGR* be set as follows: Up to 175 pages, $2.00; 175–250 pages, $3.00; 251–350 pages, $4.00; 351–450 pages, $5.00; over 450 pages, $6.00.

Geophysical Monograph Board—Chairman Alan Shapley noted that the Board had been active during the Annual Meeting and has developed the plan to proceed with one monograph relating to the proceedings of the Pacific Science Congress, and embracing topography and sediments of the Pacific, the Earth's crust in the Pacific basin, and volcanism and plutonism in relation to types of crustal deformation; and possibly a second monograph on tsunamis. We are also to pursue vigorously the development of a series of three monographs, suggested by J. A. Jacobs, relating to (1) the thermal history of the Earth, (2) theory of isotope separation in nature, and (3) thermodynamic properties of mineral substances. Shapley urged the securing of the necessary funds in order that these might proceed without delay. A second series relating to the Antarctic, probably of a larger format than the present geophysical monograph series, would bear on various phases of Antarctic studies. Six titles have been suggested.

A motion was made and approved that

> The balance shown in Schedule 9 of the budget (Appendix 2) should be made available immediately to the Geophysical Monograph Board, and steps should be taken to see what arrangements can be made with the National Science Foundation to transfer the monograph balances from Monograph Nos. 3, 4, and 5 (Schedule 7) to this fund and to augment the fund, if possible, in order that future monographs may be carried in a general monograph fund.

Audit—The Committee on Audit presented the report shown as Appendix 1. A motion was made and passed that

> The report presented by the Audit Committee should be approved.

Budget—The Executive Committee on March 25 agreed to recommend to the Council the budget shown as Appendix 2, it now being noted that the geophysical monograph fund shown in Schedule 9 has been made available (by action noted above) for use by the Geophysical Monograph Board, and that steps are to be taken to see if the balance on the accounts for Monographs 3, 4, and 5 (see Schedule 7) supported by grants from the National Science Foundation might also be transferred to our general monograph fund.

After discussion, it was moved and passed that

> The budget as presented in Appendix 2 should be approved.

Membership—Chairman Earl Droessler was not present. The report set forth as Appendix 3 was presented. With regard to the establishment of a grade of Fellow, Chairman Droessler had worked closely with Acting Chairman Walter B. Langbein of the Committee on Statutes and By Laws, and, to implement the recommendation, had drawn up a revision of the By Laws. A motion was made and approved that

> The following new articles should be added to the statutes: *Article* 3(h) *Fellows:* Fellows of the American Geophysical Union shall be scientists who have attained acknowledged eminence in some branch of geophysics. All members of the National Academy of Sciences who are members of the AGU shall be Fellows. Other Fellows may be elected from the membership of the AGU by a Committee of 11 Fellows appointed by the President, with the proviso that the total number of Fellows so elected in 1961 shall not exceed one hundred and that the number so elected to the rank of Fellow in any subsequent calendar year shall not exceed ten.

The list of delinquent members was reviewed and a motion was made and passed that

> One more effort should be made to return these delinquent members to active membership following which, if this is not successful, they shall be dropped from membership as provided by the Statutes and By Laws.

Statutes and By Laws—When the Statutes and By Laws were modified rather extensively in 1960 to provide for the new Council and for other changes, it was noted by the National Academy of Sciences that the preamble no longer conformed to the organization of the NAS-NRC. Accordingly, the recommendation was made that the preamble be revised to omit the words "and the Council of the American Geophysical Union is the Committee on Geophysics of the National Research Council."

It was moved and approved that

> The preamble will read "The American Geophysical Union is hereby established by the National Research Council. The Council of the American Geophysical Union is the United

States National Committee of the International Union of Geodesy and Geophysics."

This will be referred to the membership for ballot.

At the Executive Committee Meeting on October 22, 1960, initial action was taken to amend By Law 1 so that the fiscal year will correspond to the calendar year. A second action making this effective was recommended by the Executive Committee. A motion was made and passed that

> By Law 1 should now read "The fiscal year of the American Geophysical Union shall conform to the calendar year."

Geophysical and Geological Study of Continents—Chairman George P. Woollard noted that, although the new committee of the Geophysics Research Board, of which he is a member, is undertaking work similar to that of his long standing Committee on Geophysical and Geological Study of Continents, the latter Committee should be continued at least until such time as it is determined to what degree the new Committee will pick up and support this activity.

Planetary Sciences—Homer E. Newell, Chairman, and Robert Jastrow, Secretary, were unable to be present but were represented by Gordon J. F. MacDonald. The Committee had submitted an extended report before the Executive Committee Meeting on March 25 which, with revisions as approved by the Executive Committee, is set forth as Appendix 4. Note the three recommendations near the end of the appendix. In the interim there has been extensive discussion of the pros and cons of this problem; several motions were introduced relative to the proposed plan, but none of the motions received a majority vote. President Berkner appointed an *ad hoc* Committee consisting of Thomas F. Malone, Chairman, L. R. Alldredge, and Gordon J. F. MacDonald, to consider the matter immediately and to recommend a motion. The motion was subsequently made and approved that

> The Council has considered the proposal of the Planning Committee on Planetary Sciences that a Section on Planetary Sciences be established within the Union and has received the recommendation of the Executive Committee that this proposal be approved. The Council favors the establishment of this section but believes that this action should be taken concurrently with an examination of the section structure of the Union and a review of need for a change in the name of the Union to reflect more faithfully the scope of the exciting scientific activities now encompassed by the Planning Committee on Planetary Sciences. The Council directs the President to appoint a Special Study Group to prepare, for action by the Council at the fall meeting, recommendations on (1) the manner in which the structure of the Union should be revised to provide an appropriate place in the Union for the interests represented by the Committee on Planetary Sciences, and (2) a change in the name of the Union, if this is considered to be desirable.

(The following were subsequently appointed to the Special Study Group; Philip H. Abelson, Chairman, Leroy Alldredge, A. J. Dessler, Robert Jastrow, Walter B. Langbein, Gordon J. F. MacDonald, Peter Meyer, Morris Neiburger, A. O. C. Nier, Hugh Odishaw, Frank Press, Alan H. Shapley, James Van Allen, and William S. von Arx.)

John A. Fleming Award—Fred Agnich, Chairman, was not present. It was noted that the fund now in hand totals more than **$5,000**, and if the Committee can secure the **$3,000** originally sent to Dr. Fleming and returned by him to the donors, and the pledge of about **$2,000** that the Chairman of the Committee has, the fund would then reach **$10,000**, which has been the goal. The Council requested the Executive Secretary to work with Chairman Agnich and to take steps as promptly as possible to complete the fund and the specifications and procedure for the Award, the latter in line with the recommendations of E. H. Vestine, with the expectation that the fund may be complete during the current calendar year and possibly an award be made in 1962.

Promotion—Chairman Earl G. Droessler attempted to arrange a meeting of the Committee during the Annual Meeting. This failed and he plans to take steps to work out a program by other means.

James B. Macelwane Award—Earl G. Droessler, Chairman, was not present. It was noted that this award had been considered by the Executive Committee on March 25 and referred back to Chairman Droessler to outline the principles and purposes of the award. The recommendations made by the Executive Committee and presented on March 25, and the supplement based on these recommendations are set forth as Appendix 5.

It was felt that action on this matter should be deferred until the fall meeting of the Council.

Reports of Sections

Geodesy—A visiting scientist program has been under study by the Section of Geodesy, and several meetings have been held to discuss this matter, but it was reported that no recommendations are being made at this time.

Oceanography—Vice President Pritchard presented the report of the study with regard to the Journal of Geophysical Research as set forth in Appendix 6.

New Business

The terms of office of many new members of the present Council terminate on June 30, 1961, notably those who are Presidents of Sections and representatives of the Section Presidents, and accordingly, the Executive Committee should be reconstituted. Under By Law 3, there are four *ex officio* members of the Executive Committee; five members of the Council are to be recommended by the Council to the National Academy of Sciences for appointment to the Executive Committee, and these should be designated by July 1, if possible. The President requested the President-Elect to designate a committee to bring in nominations to be presented to the Council as a whole. President-Elect Thomas F. Malone designated J. W. Joyce, Chairman, George P. Woollard, and A. Nelson Sayre to be this committee. A ballot is to be circulated to the new Council members in advance of July 1 and the results forwarded to the Academy as the Council's recommendation, so that the new Executive Committee may be in full standing as of that date.

Forty-Third Annual Meeting—L. Thomas Aldrich, Chairman for the Forty-Second Eastern Meeting was not present. The meeting in the week preceding the National Academy of Sciences' meeting appeared to work out very satisfactorily this year, and it was recommended that we should attempt to work out similar dates for 1962. There is still uncertainty as to whether the National Academy of Sciences Meeting will start on Monday, April 30, 1962, or a week earlier, April 23, 1962. Accordingly, dates for the Eastern National Meeting are not yet fixed. (Editor's Note: The meeting of the Academy has since been set for April 23, but as the previous week was found to be undesirable, the AGU meeting has been scheduled for April 25–28.)

There was discussion of the need of a second Council Meeting each year. It was deemed that this should appropriately be held in connection with the Western National Meeting in late December, even though this predates the Eastern National Meeting (the Annual Meeting) by only four months.

The Council then went into brief Executive session, and upon the recommendation of the *ad hoc* Salary Committee (Thomas F. Malone, F. W. Reichelderfer, A. Nelson Sayre) made an adjustment in the salary of the Executive Secretary that was deemed to be appropriate.

The meeting adjourned at 12h 34m.

A. Nelson Sayre, *General Secretary*
Waldo E. Smith, *Executive Secretary*

Appendix 1—Report of the Committee on Audit

April 17, 1961

A. G. McNish, *Chairman*

A. P. Crary Elliott B. Roberts

The Committee on Audit has examined the reports of Garland C. Owens, Certified Public Accountant, for the year ending June 30, 1960, and for the half-year ending December 31, 1960. The Committee has verified to its satisfaction that the affairs of the Union are in accordance with the auditor's statement, and in particular in connection with the June 30 report, the Committee has verified not only the bank statements but has examined the securities reportedly held at that time by the Union, and found them to be as set forth in the report for that time, which has been published in the *Transactions,* Vol. 42, No. 1, March 1961, pages 86–91.

The Committee is pleased with the new accounting system, which has been set up by Dr. Owens and which reflects the financial affairs of the Union on a basis consistent with the increased stature of the Union and magnitude of its operation. Dr. Owens is to be congratulated on the very excellent accounting system which he has established.

The following Balance Sheet as of December 31, 1960, and statements of Income and of Fund Activities for the period July 1, 1960 to December 31, 1960 were examined by Dr. Owens who, in a letter dated March 10, 1961, stated as follows:

'In my opinion the accompanying balance sheet and the related statement of income and supporting schedules present fairly the financial position of the American Geophysical Union at December 31, 1960, and the results of its operations for the six-month period then ended, in accordance with generally accepted principles of accounting.'

SCHEDULE A

Balance Sheet
December 31, 1960

Current Assets:			
Cash—Regular Account			$ 31,332.91
Cash—Savings Accounts			100,727.22
U. S. Treasury Securities, at cost			103,497.70
Accounts Receivable			39,722.09
Interest Receivable			1,729.83
Prepaid Expenses			670.49
			$277,680.24
Current Liabilities:			
Accounts Payable		$ 22,843.05	
Deferred Income—1961 & 1962		41,230.12	
Funds:			
JGR Fund (Schedule 1)	$ 57,612.37		
Trudy (Schedule 2)	4,271.50		
Izvestiya 1957 (Schedule 3)	2,335.10		
Izvestiya 1958 (Schedule 4)	11,745.77		
Izvestiya 1959 (Schedule 5)	11,225.14		
Izvestiya 1960 (Schedule 6)	25,120.85		
Izvestiya 1961	(170.00)		
Monograph No. 3 (Schedule 7)	1,849.83		
Monograph No. 4 (Schedule 8)	4,933.29		
Monograph No. 5 (Schedule 9)	(144.53)		
Asia Foundation (Schedule 10)	1,845.30		
IUGG Triennial Report (Schedule 11)	1,838.36		
Geodesy & Cartography (Schedule 12)	16,779.49		
T. M. & E. Award Fund	5,347.91	144,590.38	208,663.55
Excess of Current Assets over Current Liabilities			$ 69,016.69
Office Equipment, at cost (less depreciation of $213.30)			4,541.40
Surplus:			
Permanent:			
Balance June 30, 1960	$ 21,419.44		
Add: Adjustment of prior periods	12.81		
Contributions	323.19		
Interest	629.70	$ 22,385.14	
Operating:			
Balance June 30, 1960	$ 51,833.68		
Less: Adjustment of prior period	(12.81)		
Deficit for the period July 1, 1961, to December 31, 1960, per Schedule B	(647.92)	51,172.95	
Net Assets			$ 73,558.09

SCHEDULE B

Statement of Income, Administration Account
For the period July 1, 1960 to December 31, 1960

Revenues:		
Dues (Note 2)	$ 8,475.06	
Monograph Sales (Nos. 1 & 2) (net)	134.37	
Interest Income	3,811.51	
Miscellaneous Income	281.52	
Overhead earned on grants:		
Monographs (Schedules 7, 8, and 9)	43.62	
Russian Translation (Schedules 2, 3, 4, 5, 6, and 12)	7,205.83	
Triennial Report (Schedule 11)	135.01	
Asia Foundation (Schedule 10)	79.75	
Overhead charged to projects:		
Journal of Geophysical Research (Schedule 1)	13,530.68	
Transactions (Schedule 13)	1,481.89	
Total Revenues		$ 35,179.24
Charges:		
Salaries, FICA & Retirement Contribution	$ 25,081.59	
Promotion	587.10	
Office Supplies and Expenses	1,391.36	
Communications	1,013.29	
Premise	3,873.60	
Equipment Depreciation	213.30	
Professional Services	400.00	
Travel	1,376.63	
President's Fund	84.46	
Membership:		
Printing and Mailing	550.61	
Meetings	227.83	
Committees and Sections	152.23	
Loss on Transactions Activities (Schedule 13)	875.16	
Total Charges		$ 35,827.16
Deficit for the period July 1, 1960 to December 31, 1960		($ 647.92)

SCHEDULE 1

JOURNAL OF GEOPHYSICAL RESEARCH FUND ACTIVITIES

For Period July 1, 1960 to December 31, 1960

Fund Balance at July 1, 1960		$ 55,764.26
Revenues:		
Dues (Note 2)	$ 14,125.10	
Subscriptions	21,159.35	
Page Charges	42,831.00	
Reprints	18,274.35	
Back Issue Sales	2,415.15	
Advertising	5,578.34	
Grants	1,200.00	
Total Revenues	$105,583.29	
Charges:		
Editorial Office		
Salaries	$ 3,225.64	
Honoraria	2,000.00	
Expenses	2,221.85	
Salaries (AGU office)	4,567.34	
Printing and Mailing	71,129.72	
Materials, Supplies, and Services	204.18	
Reprints	6,184.05	
Promotion	671.72	
Administration (Note 3)	13,530.68	
Total Charges	$103,735.18	
Net Change in Fund		$ 1,848.11
Fund Balance at December 31, 1960		$ 57,612.37

SCHEDULE 2

TRUDY FUND

For Period July 1, 1960 to December 31, 1960

Balance at June 30, 1960			$ 3,336.32
Sales		$ 4,990.04	4,990.04
			$ 8,326.36
Salaries and FICA	$ 71.38		
Printing and Mailing	3,184.84		
Translation No. 40	269.75		
Administration (Note 3)	528.89		4,054.86
Unexpended Balance at December 31, 1960			$ 4,271.50

SCHEDULE 3

1957 IZVESTIYA FUND

For Period July 1, 1960 to December 31, 1960

Balance at June 30, 1960			$ 2,794.79
Sales		$ 2,201.00	2,201.00
			$ 4,995.79
Salaries and FICA	$ 74.63		
Translations, Printing and Mailing	2,131.12		
Advertising	107.89		
Administration (Note 3)	347.05		2,660.69
Unexpended Balance at December 31, 1960			$ 2,335.10

SCHEDULE 4

1958 IZVESTIYA FUND
For Period July 1, 1960 to December 31, 1960

Balance at June 30, 1960			$ 10,324.20
Sales		$ 1,607.50	1,607.50
			$ 11,931.70
Salaries and FICA	$ 12.02		
Mailing	41.78		
Advertising	107.88		
Administration (Note 3)	24.25		185.93
Unexpended Balance at December 31, 1960			$ 11,745.77

SCHEDULE 5

1959 IZVESTIYA FUND
For Period July 1, 1960 to December 31, 1960

Balance at June 30, 1960			$ 26,315.24
Sales		$ 2,397.50	2,397.50
			$ 28,712.74
Salaries and FICA	$ 187.80		
Printing and Mailing	14,795.48		
Materials, Services, and Supplies	92.00		
Advertising	131.33		
Administration (Note 3)	2,280.99		17,487.60
Unexpended Balance at December 31, 1960			$ 11,225.14

SCHEDULE 6

1960 IZVESTIYA FUND
For Period July 1, 1960 to December 31, 1960

August 17, 1960—NSF Grant G14115			$ 20,000.00
Nov. 17, 1960—NSF Grant G14115			20,000.00
			$ 40,000.00
Sales		$ 6,904.00	6,904.00
			$ 46,904.00
Salaries and FICA	$ 305.90		
Printing and Mailing	6,766.89		
Materials, Services, and Supplies	387.72		
Translations, including Editor	11,328.00		
Advertising	153.36		
Administration (Note 3)	2,841.28		21,783.15
Unexpended Balance at December 31, 1960			$ 25,120.85

SCHEDULE 7

FUND FOR CINCINNATI CONFERENCE AND MONOGRAPH NO. 3
For Period July 1, 1960 to December 31, 1960

Balance at June 30, 1960			$ 1,668.28
Sales		$ 240.89	240.89
			$ 1,909.17
Salaries and FICA	$ 6.83		
Mailing	8.75		
Materials, Services, and Supplies	.73		
Advertising	35.29		
Administration (Note 3)	7.74		59.34
Unexpended Balance at December 31, 1960			$ 1,849.83

SCHEDULE 8

Fund for Cambridge Conference and Monograph No. 4
For Period July 1, 1960 to December 31, 1960

Balance at June 30, 1960			$ 4,750.51
Sales		$ 232.26	232.26
			$ 4,982.77
Salaries and FICA	$ 1.50		
Mailing	5.50		
Materials, Services, and Supplies	.73		
Advertising	35.30		
Administration (Note 3)	6.45		49.48
Unexpended Balance at December 31, 1960			$ 4,933.29

SCHEDULE 9

Fund for Woods Hole Conference and Monograph No. 5
For Period July 1, 1960 to December 31, 1960

Balance at June 30, 1960			($ 1,909.02)
Sales		$ 1,990.15	1,990.15
			$ 81.13
Salaries and FICA	$ 14.78		
Mailing	24.95		
Materials, Services and Supplies	2.34		
Reprints	118.82		
Advertising	35.34		
Administration (Note 3)	29.43		225.66
Unexpended Balance at December 31, 1960			($ 144.53)

SCHEDULE 10

Asia Foundation Fund
For Period July 1, 1960 to December 31, 1960

Balance at June 30, 1960		$ 2,456.71
Salaries and FICA	$ 18.66	
JGR Subscriptions (19 @ $18)	342.00	
Dues (1 @ $10; 14 @ $9)	136.00	
Student Dues (4 @ $3.50)	14.00	
Transactions Subscriptions (7 @ $3)	21.00	
Administration (Note 3)	79.75	611.41
Unexpended Balance at December 31, 1960		$ 1,845.30

SCHEDULE 11

IUGG Triennial Report
For Period July 1, 1960 to December 31, 1960

Balance at June 30, 1960			($ 1,535.54)
July 8, 1960: Additional Grant		$ 4,400.00	
Sales		9.00	4,409.00
			$ 2,873.46
Printing and Mailing	$ 896.62		
Materials, Services, and Supplies	3.47		
Administration (Note 3)	135.01		1,035.10
Unexpended Balance at December 31, 1960			$ 1,838.36

SCHEDULE 12

1959 Geodesy and Cartography Fund
For Period July 1, 1960 to December 31, 1960

July 14, 1960—NSF Grant G-13594			$ 25,466.00
Sales		$ 386.00	386.00
			$ 25,852.00
Salaries and FICA	$ 75.88		
Printing and Mailing	4,087.50		
Materials, Services, and Supplies	117.64		
Translation Consultants	468.00		
Translations	2,880.00		
Advertising	260.12		
Administration (Note 3)	1,183.37		9,072.51
Unexpended Balance at December 31, 1960			$ 16,779.49

SCHEDULE 13

Transactions Activities
For period July 1, 1960 to December 31, 1960

Revenues:		
Dues (Note 2)	$ 5,650.04	
Subscriptions	2,784.09	
Reprints	891.00	
Back issue sales	578.92	
Advertising	573.96	
IGY Bulletins	4,963.13	
Miscellaneous	8.00	
Total Revenues		$ 15,449.14
Charges:		
Salaries (AGU office)	$ 2,783.20	
Printing and Mailing	6,945.43	
Materials, Services, and Supplies	34.34	
Reprints	116.31	
IGY Bulletins	4,963.13	
Administration (Note 3)	1,481.89	
Total Charges		$ 16,324.30
Net loss* for period July 1, 1960 to December 31, 1960		($ 875.16)

* Loss on Transactions is charged to income in Schedule B.

Notes to Financial Statements:

Note 1: The American Geophysical Union is an unincorporated affiliate of the National Academy of Sciences and operates under the corporate charter of that organization. In its operations and accounting, the American Geophysical Union conducts its affairs as an autonomous organization.

At the October 22, 1960 meeting of the Executive Committee, the fiscal year of the American Geophysical Union was changed from June 30 to December 31.

Note 2: Members' dues are allocated as follows: Administration, 30%; *Journal of Geophysical Research*, 50%; *Transactions*, 20%; Total, 100%.

The above allocation is subject to change as the conditions may warrant.

Note 3: The American Geophysical Union charges the various projects and grants, including the *Journal of Geophysical Research* and *Transactions*, for administration costs. The present overhead rate is 15 per cent of the direct costs charged to the project or grant. In the case of *Transactions*, the cost of IGY Bulletins are reimbursable and these costs have been excluded from direct costs in applying the overhead rate.

Appendix 2—Report of the Committee on Budget

JOHN C. REED, *Chairman* (to March 25, 1961)
LOUIS O. QUAM, *Chairman* (from March 25, 1961)
L. T. ALDRICH

The following budget for the fiscal year ending December 31, 1961, was accepted by the Executive Committee on March 25, and recommended to the Council.

BUDGET FOR FISCAL YEAR ENDING DECEMBER 31, 1961

SCHEDULE 1

STATEMENT OF INCOME
(Administration Account)

Revenues:		
Dues (30%, see Schedule 4)	$ 19,755.00	
Monograph Sales (Nos. 1 and 2) (net)	380.00	
Interest Income	8,000.00	
Miscellaneous Income	500.00	
Overhead earned on grants:		
Monographs (Schedules 7 & 9)	62.00	
Russian Translations (Schedules 5 & 6)	12,277.00	
Asia Foundation (Schedule 8)	236.00	
Overhead charged to projects:		
Journal of Geophysical Research (Schedule 2)	33,129.00	
Transactions (Schedule 3)	2,235.00	$ 76.574.00
Charges: (Administration Expenses)		
Salaries, FICA & Ret. Contribution	$ 54,000.00*	
Equipment	2,000.00	
Promotion	1,500.00	
Office Supplies and Expenses	3,000.00	
Communications	3,000.00	
Premise	7,800.00	
Professional Services	1,200.00	
Travel and Official Expenses	4,000.00	
Bowie Medal	130.00	
President's Fund	100.00	
Membership:		
Printing and Mailing	800.00	
Meetings	2,100.00	
Committees and Sections	400.00	$ 80,030.00
Balance Administration Account		($ 3,456.00)

* Including about $2,000 to implement action of the Executive Committee in April 1960 to establish an annuity of $10,000 for the Executive Secretary (see September 1960 *Transactions*, p. 475)

Summary of Balances

Administration account	($ 3,456.00)	
JGR account	(25,564.00)	
Charge to JGR fund		$ 25,564.00
Transactions account		4,835.00
Net Balance		$ 1,379.00

SCHEDULE 2

JOURNAL OF GEOPHYSICAL RESEARCH FUND ACTIVITIES
Proposed Budget for Fiscal Year Ending December 31, 1961

Fund Balance at December 31, 1960	$ 57,612.00
Revenues:	
Dues (50%, see Schedule 4)	32,925.00
Subscriptions	42,000.00
Page Charges	90,000.00
Reprints	30,000.00
Back Issue Sales	5,000.00
Advertising	12,000.00
Grants	16,500.00
Total Revenues	$228,425.00
Charges:	
Editorial Office:	
Salaries	$ 11,260.00
Honoraria	7,000.00
Expenses	4,000.00
Salaries (AGU office)	13,000.00
Printing and Mailing	170,000.00
Materials, Supplies, and Services	600.00
Reprints	13,000.00
Promotion	2,000.00
Administration (15% of direct cost, Schedule 1)	33,129.00
	$253,989.00
Net Change in Fund	(25,564.00)
Fund Balance at End of Period	$ 32,048.00

SCHEDULE 3

TRANSACTIONS ACTIVITIES
Proposed Budget for Fiscal Year Ending December 31, 1961

Revenues:	
Dues (20%, see Schedule 4)	$ 13,170.00
Subscriptions	5,500.00
Reprints	600.00
Back issue sales	1,000.00
Advertising	1,200.00
IGY Bulletins	9,000.00
Grant—NAS-NRC	400.00
Miscellaneous	100.00
Total Revenues	$ 30,970.00
Charges:	
Salaries (AGU office)	$ 5,600.00
Printing and Mailing	9,000.00
Materials, Services, and Supplies	100.00
Reprints	200.00
IGY Bulletins	9,000.00
Administration (15%*, Schedule 1)	2,235.00
Total Charges	$ 26,135.00
Excess of Revenues over Charges	$ 4,835.00

* Exclusive of IGY Bulletins

SCHEDULE 4

Distribution of Dues

Budget for Fiscal Year Ending December 31, 1961

Classification	Yearly Rate	No.	Proposed Budget Amount
Members (regular and associate)	$ 10.00	6000	$60,000.00
Life members	0	100	0
Student members	4.50	300	1,350.00
Corporation members	100.00	45	4,500.00
Contributing members	500.00		0
Sustaining members	1,000.00		0
Benefactors	5,000.00		0
			$65,850.00

Allotment of Dues

To JGR	50% (Schedule 2)	$32,925.00
To Transactions	20% (Schedule 3)	13,170.00
To Administration	30% (Schedule 1)	19,755.00
		$65,850.00

SCHEDULE 5

Izvestiya Funds

Proposed Budget for Fiscal Year Ending December 31, 1961

1957–1958–1959 Izvestiya Funds

December 31, 1960 Balance 1957		$ 2,335.00	
Balance 1958		11,746.00	
Balance 1959		11,225.00	$ 25,306.00
Estimated Sales		$ 3,000.00	3,000.00
			$ 28,306.00
Salaries and FICA	$ 200.00		
Mailing	350.00		
Advertising	200.00		
Administration (15%)	113.00		863.00
Unexpended Balance, December 31, 1961			$ 27,443.00

1960 Izvestiya Fund

December 31, 1960 Balance			$ 25,121.00
March 1961 NSF Grant G 14115			17,730.00
			$ 42,851.00
Estimated Sales		$ 5,000.00	5,000.00
			$ 47,851.00
Salaries and FICA	$ 350.00		
Translation Editor (5 @ $450)	2,250.00		
Translations (737 pp.)	4,422.00		
Printing & Mailing (nos. 4–12)	22,000.00		
Materials, Services, & Supplies	300.00		
Advertising	200.00		
Administration (15%)	4,428.00		33,950.00
Unexpended Balance, December 31, 1961			$ 13,901.00

1961 Izvestiya Fund

March 2, 1961 NSF Grant			$ 15,000.00
May 15, 1961 NSF Grant			15,000.00
August 15, 1961 NSF Grant			15,000.00
November 15, 1961 NSF Grant			10,790.00
			$ 55,790.00
Estimated Sales		$ 5,000.00	5,000.00
			$ 60,790.00
Salaries and FICA	$ 350.00		
Translation Editor (7 @ $450)	3,150.00		
Translations (1363 pp.)	8,178.00		
Printing & Mailing (1–3)	6,800.00		
Materials, Services, & Supplies	400.00		
Advertising	200.00		
Administration (15%)	2,862.00		21,940.00
Unexpended Balance, December 31, 1961			$ 38,850.00

SCHEDULE 6

Geodesy and Cartography Funds

Proposed Budget for Fiscal Year Ending December 31, 1961

1959 Geodesy and Cartography Fund

Unexpended Balance, December 31, 1960			$ 16,779.00
Estimated Sales		$ 1,600.00	1,600.00
			$ 18,379.00
Translation Consultants	$ 468.00		
Translations	2,880.00		
Composition & Printing 5–12	8,160.00		
Promotion	240.00		
Salaries & FICA	100.00		
Administration (15%)	1,777.00		13,625.00
Unexpended Balance, December 31, 1961			$ 4,754.00

1960 Geodesy and Cartography Fund

March 1961 NSF Grant			$ 14,335.00
August 1961 NSF Grant			10,000.00
			$ 24,335.00
Estimated Sales		$ 2,000.00	2,000.00
			$ 26,335.00
Translation Consultants (12 × 78 pp.)	$ 936.00		
Translations (12 × 80 × $7)	6,720.00		
Composition & Printing (12 × 80 × $12.75)	12,240.00		
Promotion	500.00		
Salaries & FICA	200.00		
Subscriptions	50.00		
Administration (15%)	3,097.00		23,743.00
Unexpended Balance, December 31, 1961			$ 2,592.00

SCHEDULE 7

MONOGRAPH FUNDS

Proposed Budget for Fiscal Year Ending December 31, 1961

Funds for Monographs Numbers 3–5

December 31, 1960 Balance No. 3			$ 1,850.00
Balance No. 4			4,933.00
Balance No. 5			(144.00)
			$ 6,639.00
Estimated Sales		$ 1,500.00	1,500.00
			$ 8,139.00
Salaries & FICA	$ 75.00		
Mailing	150.00		
Advertising	100.00		
Administration (15%)	49.00		374.00
Unexpended Balance, December 31, 1961			$ 7,765.00

SCHEDULE 8

ASIA FOUNDATION FUND

Proposed Budget for Fiscal Year Ending December 31, 1961

December 31, 1960: Balance			$ 1,845.00
Add: Salaries (not allowed)	$ 19.00		
Administration 15% on above	3.00		22.00
			$ 1,867.00
JGR Subscriptions 20 @ $18		$ 360.00	
Transactions Subscriptions 7 @ $3		21.00	
Membership Dues 20 @ $9		180.00	
Student Dues 5 @ $3.50		18.00	
Travel Expenses for Foreign Scientists to attendMeetings		1,000.00	
Administration (15%)		236.00	1,815.00
Unexpended Balance, December 31, 1961			$ 52.00

SCHEDULE 9

THE GEOPHYSICAL MONOGRAPH FUND*

Proposed Budget for Fiscal Year Ending December 31, 1961

December 31, 1960, Balance			$ 4,656.00
Estimated Sales		$ 478.00	478.00
			$ 5,134.00
Salaries & FICA	$ 10.00		
Mailing	25.00		
Advertising	50.00		
Administration (15%)	13.00		98.00
Unexpended Balance, December 31, 1961			$ 5,036.00

* Transferred from Operating Surplus; per
Executive Committee Meeting of October 22, 1960.

Appendix 3—Report of the Committee on Membership

Earl G. Droessler, *Chairman*

Willis B. Foster John R. Gerhardt Elliott B. Roberts

Through the good offices of the Executive Secretary, we have circularized the members of the American Physical Society with applications for membership and appropriate promotional literature. The results to date are encouraging, and completed forms continue to come in. About 150 physicists have already been attracted to the AGU through this effort. Next on the list to circularize are the American Meteorological Society and the Society of Exploration Geophysicists.

Corporation Membership Chairman Elliott B. Roberts has launched a fresh campaign to sign up more corporation memberships. Eight new applications have been received since the middle of December in response to his first group of 200 letters.

The Membership Committee has initiated a new program to extend the effectiveness of its activities through the appointment of Adjunct Members of the Membership Committee for various areas of the country. Adjunct Members will keep a ready supply of AGU membership forms and promotional literature available and offer it for display on appropriate occasions. They will ask their scientific colleagues to consider AGU membership, pointing out its many advantages, such as receiving AGU publications regularly. Adjunct Members should be especially alert in sending to the Executive Secretary lists of attendants at all meetings where geophysical research is discussed in whole or in part. With expanding activities in geophysics, the screening of such lists offers a direct means for AGU to keep in the forefront on membership. About 50 or more Adjunct Members will probably be appointed.

The General Secretary's report carries the usual statistics on membership growth.

During January and February of this year, President Berkner sent letters to our corporation members requesting that they consider increasing the status of their memberships, in accordance with the revised Statutes, to Supporting Members. Three favorable responses have been received so far, as follows: United Gas Corporation, and Benedix Aviation Corporation as Sustaining Members, at $1000 each, and Mobil Oil Company as Contributing Member, at $500.

In addition, Geophysics Corporation of America (Bedford, Massachusetts) has indicated that they are considering the Contributing Member status ($500) when their membership expires September 30. Hughes Aircraft advises that for 1961 they can make no change but are seriously considering another class in 1962. Western Geophysical Company notes that they have 'always contributed heavily to the professional advancement of exploration geophysics. As we grow more active in those areas of interest represented within the Union, I am sure you will find us lending generous support to it.'

When a company enters as a Supporting Member, a ballot is sent to the members of the Council for vote. The question is here raised whether, in cases of change of status from a lower to a higher type of Supporting Member, a ballot should also be submitted to the Council.

Establishment of Rank of Fellow—At the last meeting of the Executive Committee it was agreed that the Membership Committee should study the suggestion that AGU establish the rank of Fellow. The Committee was asked to consult with some of the 'elder statesmen' of AGU in carrying out its task. A report follows on the highlights of our activities, and concludes by offering a recommendation for consideration by the Council.

The Membership Committee found high endorsement and considerable sentiment for the establishment of the grade of Fellow. Those consulted by correspondence were Walter H. Bucher, Leason H. Adams, W. D. Lambert, Maurice Ewing, and Joseph Kaplan.

A feeling was general that election to the ranks of the AGU Fellows should be made by a special board or committee appointed by the President. One suggestion was that all AGU members who are also members of the National Academy of Sciences would be automatically appointed as Fellows, and that this group might comprise the initial special board for the election of new Fellows. Such an action, I believe, would meet a strongly expressed view that AGU fellowship should be a highly coveted honor and be recognized to be almost as significant as election to the Academy. On the same theme, the number of Fellows elected each year should be limited; in this connection a limitation to ten American and two foreign scientists was mentioned. Another suggested limit would allow Fellows to be elected in a stated proportion of the total membership of AGU.

One cogent reason expressed for the creation of the rank of Fellow was that government agencies, the press, school authorities, and many citizens and groups outside the particular field of science require authoritative advice as to who are the most competent workers in the field, and it is the duty of the scientific organizations to provide such information. Another good reason centers on the importance of motivating AGU members to perform research and to give services of the highest quality. Fellowship would provide appropriate recognition for such excellence.

It was suggested also that the awards of fellowship could be made part of an Honors Night Dinner of the AGU, and that this might be held in the East and the West in alternate years. It was felt that this would add considerably to the growing prestige of the AGU.

As the result of the study made, the Membership Committee recommends that the AGU establish the rank of Fellow and that the Council consider an overall plan and schedule for the election of AGU Fellows.

Appendix 4—Report of the Planning Committee on Planetary Sciences

Homer E. Newell, *Chairman*
Robert Jastrow, *Secretary*

P. H. Abelson
L. R. Alldredge
J. W. Chamberlain
Thomas Gold
G. J. F. MacDonald
Hugh Odishaw
A. H. Shapley
E. H. Vestine
C. A. Whitten
Harry Wexler

Research in the planetary sciences has entered on a period of vigorous expansion in the past two years. The degree of expansion is indicated by a twenty-fold increase in the number of papers on planetary sciences published in the *Journal of Geophysical Research* in the period from 1958 to 1960.

As interest develops in this area of research, it becomes increasingly evident that a formal unit must be established within the organized framework of scientific research in this country, to serve the interests of the continuously increasing number of scientists participating in the space program of the United States.

One year ago the President of the American Geophysical Union (AGU) created the *ad hoc* Planning Committee on Planetary Science in recognition of the need for such an organizational unit. The Committee has participated in the arrangements for two national AGU meetings, a regional conference, and a jointly sponsored AGU-APS symposium at the December 1961 meeting of AAAS. The experience accumulated by the Planetary Science Committee in these activities during the past year now provides a basis for considering effective means of future action in developing the potentialities of the Union for serving the interests of its members who are interested in the planetary sciences. The very substantial total of 68 significant papers was contributed to the 1960 meeting, and 67 papers for the 1961 meeting had been received up to the February 10 deadline, with post-deadline papers continuing to arrive. All sessions at the 1960 meeting were attended by large audiences.

The discussion of modes for further development of AGU activity in the planetary sciences can best be discussed in the context of all organized activity in the physical sciences within the United States. Several alternatives exist within this broader statement of the question.

First, a new society might be formed, with members drawn from the existing national societies in the physical sciences, and with a program devoted exclusively to planetary and space research. Such a society would provide the advantage of a clearly recognized home for the space sciences. On the other hand, a new society would have to draw on the scientific community for the financing of its activities and the staffing of its organization. This responsibility must be added to the burden of operating the established societies, which already constitutes an alarmingly severe drain on the energies of scientists, and a serious interference with their research. Furthermore, the creation of a new society would increase the repetition of programs in national meetings and symposia, whereas the prime objective should be the reduction of the present degree of repetition. It is certain that the major existing societies will not suppress their interest in this area of research in deference to a new society; its formation would, therefore, add still other national meetings on space research to the large number now held each year.

A second possibility is the establishment of a Joint Planetary Science Commission among the societies that have interests in this field. These would include the American Geophysical Union, the American Physical Society, the American Astronomical Society, and the U. S. National Committee for URSI. The establishment of a joint commission would provide coordination of program activities, and a broad basis of support in the scientific community. On the other hand, it would provide no real home for the planetary and space sciences unless the individual societies were to provide full support through the creation of formal units within their own structures. Without this backup from planetary and space science sections in each society, the joint commission would necessarily be an ineffective unit with ambiguous responsibilities. In that case the apparent advantage of a broad base of participation would be only illusory.

A third possibility is the continuation of the existing committee. This alternative has the advantage that it serves to draw attention to the planetary sciences, and still eliminate the necessity for extensive organizational changes. Furthermore, the Committee could continue to draw on existing sections of the AGU for assistance and support. To continue the Committee in its present form would carry the disadvantage, in our view, that it would not give the full attention to the planetary sciences that they deserve in view of their growing importance in the Earth sciences. The organizational status of a committee is weaker than that of the regularly constituted AGU section, and this difference would appear to place the planetary sciences in a secondary position with respect to the other fields of research incorporated in the AGU. By virtue of its secondary status the Committee could not be fully effective in drawing more support from the scientific community for research in this area, nor could it suitably play its passive role in reflecting the existing interests of scientists in this field.

The fourth possibility is to establish a new section within the AGU that would be devoted to the planetary sciences, which we define as research investigations related to the Moon and planets, and their atmospheres. We believe that research conducted in the planetary sciences has developed, within the last two years, into a major area of the Earth sciences. It is an area whose importance is comparable to that of the disciplines now represented by sections in the American Geophysical Union.

The Committee recognizes that a substantial overlap exists between this area of research, as so defined, and the areas covered by several of the existing sections. However, it must be pointed out that a substantial amount of overlap now occurs among several of the existing sections. The value of their separate existence is not questioned because it is clear in each case that the common denominator of research experience and training differs substantially from section to section. For example, important areas of research are shared by the meteorologists and the upper atmosphere physicists, and joint symposia and meetings have been arranged occasionally with great profit to both groups. Yet it is clear their professional motivations and viewpoints are distinct. In the same manner we consider it clear that a community of experimental and theoretical interests draws together those members of the AGU who are engaged in the development of space flight experiments related to lunar, planetary, and atmospheric investigations. The unity as a professional group is established by their common interest in the experimental problems of space flight instrumentation, and in the interpretation of the data received.

Inasmuch as the planetary sciences segment of the AGU membership exists in fact as a professional group, it is appropriate to consider the recognition of the group by the formation of a new AGU section. The research interests of such a section would indeed overlap those of other sections, and joint programs and symposia could be arranged with great profit in the future, as they have been arranged in the past between the Planetary Science Committee and the Geomagnetism and Aeronomy section.

It may be noted that until now, the formation of a section on planetary science would have been a premature action, for the professional group in planetary research has only been nascent. But with the great volume of research that developed in this area during 1960, and the establishment of well-defined patterns of research in the planetary sciences, the existence of a professional planetary science group is now established as a manifest fact, we believe that the AGU will now be derelict in its obligations to its membership if it fails to take such action in 1961.

It is, therefore, the sense of the Committee that the formation of a planetary science section must be considered by the Council of the Union as an action to be recommended to its membership for implementation by the end of 1961.

The establishment of a planetary science section within the AGU will also correspond, on a national basis, to the IUGG's interest in planetary science.

At the same time, it behooves the AGU to take the initiative in encouraging other U. S. national societies to establish similar sections for those of their members who are engaged in planetary and space research. The American Astronomical Society, the American Physical Society, and the U. S. National Committee for URSI, together with the AGU, represent the professional groups with the strongest participation in this field. The claim of the American Astronomical Society to an interest in the Moon and the planets is as legitimate as that of the AGU. The American Physical Society may be expected to develop an interest comparable to that of the AGU, in Sun-Earth relationships, and the physics of the interplanetary plasma. Finally, the U. S. National Committee for URSI has been active in the arrangement of meetings and symposia related to the physics of the ionosphere and other areas of space research. The encouragement of the APS, the AAS, and URSI to recognize the interest of their members in these fields of research will be an important contribution on the part of the AGU toward the development of space science in the United States.

However, we note that the AGU must assume equal responsibility with the scientific groups, in sponsoring planetary and space research in the United States. We adopt this view regarding the responsibility of the AGU because of the leading position taken by the *Journal of Geophysical Research* in the publication of papers on planetary sciences, and the strong support given by the AGU membership to the Planetary Science Committee in its programs arranged for national meetings.

Therefore, the Committee recommends the following actions as best serving the interests of the AGU membership and the United States scientific community participating in the planetary and space sciences program:

First, it is recommended that a new section on planetary science be established to strengthen the status of this field in the AGU. The new section would be expected to work in close cooperation with other sections in arranging technical sessions and scheduling papers and symposia.

Second, in recognition of the fact that the problems and techniques of planetary and space research are drawn also from astronomy, physics, and the Earth sciences, it is recommended that the American Physical Society, the American Astronomical Society, and the U. S. National Committee for URSI be urged to establish parallel sections.

Third, it is recommended that the Council of the AGU seek to establish a Joint Commission on Planetary and Space Science, whose members will represent the AGU, the American Physical Society, the American Astronomical Society, and the U. S. National Committee for URSI.

Appendix 5—Report of the Chairman of the Special Committee on Macelwane Award

President Ewing first asked Chairman Droessler to consider the possibilities of a Macelwane Memorial to be sponsored by the AGU. Over the past several years, the Chairman has discussed the matter with several members of the AGU, and has also spent a day at the University of St. Louis talking to Father Macelwane's former associates. Everywhere he found only enthusiasm for the idea that the AGU honor the memory of our great Past President and distinguished scientist in American geophysics. He was the man who, among many things, established the first institute of geophysics in our country, and initiated within the institute a broad range of interdisciplinary studies in the geophysical sciences. Nearly everyone spoke of Fr. Macelwane's deep interest in teaching and encouraging the young men of science.

In searching for an appropriate memorial the suggestion that met with unanimous and hearty approval was that the Council of the American Geophysical Union established the J. B. Macelwane Award to be given annually to a young scientist for the paper selected as the outstanding contribution of the year, with perhaps some consideration being given for the interdisciplinary character of the paper. Such an award could be a suitable scroll, and might eventually carry a monetary award if a patron can be found. In any event, I am certain that the Macelwane Award would immediately become one of the most cherished awards and would add immeasurably to one of AGU's prime objectives, that of providing high motivation for young, bright talent to enter the field of geophysics. I should add that it would also add incentive for membership in the AGU.

I strongly recommend to the Council the establishment of the J. B. Macelwane Award.

SUPPLEMENT

(Prepared on basis of Executive Committee recommendation of March 25, 1961)

Father Macelwane was serving the third year of his terms as President of the American Geophysical Union when he died on February 15, 1956, in the seventy-third year of his life. The biographical memoirs of the National Academy contain the following excerpts:

> "The name of James B. Macelwane has also figured in the national and the international scene, and perhaps it is his contributions here that did most to win for him the renown and respect which he enjoyed. He was a tireless promoter of any activity for the advancement of the geophysical sciences. He belonged to numerous scientific societies and his membership in each was ever of an active sort. His sympathetic interests and cooperative spirit were common knowledge and consequently his services were in frequent demand.
>
> "In conclusion, while not the greatest of his honors, one award might be singled out for special comment. It is for those of its members whose lives represent an extraordinary exemplification of the two things for which the American Geophysical Union stands, research in the Earth Sciences and cooperative effort in its prosecution, that the Union reserves its William Bowie Medal. Its motto is "Unselfish Cooperation." In 1948 this medal was conferred upon the Rev. James B. Macelwane, S.J. While the Bowie Medal was only one of the many honors Father Macelwane received, the thoughts which his memory calls forth in the minds of his friends and colleagues

throughout the world are a tribute to the singular fitness of that award."

Recommended specifications of the award:

(1) The principal purpose of that James B. Macelwane Award is to inspire young scientists in the pursuit of excellence in the geophysical sciences by recognizing those scientists of outstanding ability at the earliest possible age.

(2) *AWARD STATEMENT*—The James B. Macelwane Award is given on occasion by the American Geophysical Union in recognition of an outstanding contribution to the geophysical sciences in the published literature by a young scientist, thirty-five years of age or under.

(3) The award shall be given not more than once a year when a qualified recipient has been chosen by the AGU Macelwane Award Committee. The president shall appoint such a committee of five members to look after this matter for the Union.

Earl G. Droessler, *Chairman*

Appendix 6—Preliminary Report of the AGU Publication Committee Section of Oceanography

John Lyman, *Chairman*

Dale F. Leipper

Donald W. Pritchard

At various times in the past a number of oceanographers have expressed dissatisfaction with the present situation regarding the *Journal of Geophysical Research*. The most frequent complaint was that the oceanographic papers were submerged among a mass of material not of interest to oceanographers. As a result of these complaints the Executive Committee of the Union recommended that the Section of Oceanography appoint a committee to investigate the extent and nature of dissatisfaction, and to serve in pointing out to the Section membership the many advantages of the present policies of the *Journal*. In so doing the Committee was to bring the 'wayward' into the fold, and also encourage submission of more oceanographic papers to *JGR*. The Committee as appointed was, however, also charged with the task of recommending changes that would make *JGR* more acceptable to the major fraction of oceanographers.

At Helsinki last summer a Union committee was appointed and charged with examining the desirability and feasibility of splitting the *Journal* into two sections. D. W. Pritchard, Vice President of the Section, represented Oceanography on this committee, which met with the Editors of the *Journal* on October 7, 1960. At this meeting the majority favored continuing present policies of *JGR*. Only the representatives of the Sections of Oceanography and Hydrology indicated that some change might be desirable. Pritchard will report to the Section on further details of this meeting.

The following table gives the number of pages and the percentages of the total number of pages which each field utilized in the 1958 *Transactions* and in the 1959 and 1960 *JGR* (general subject matter not included).

In 1958, the last year of the old AGU *Transactions*, oceanographic papers occupied 115 pages or 14.7% of the total. In 1959, the first full year of

	1958 AGU		1959 *JGR*		1960 *JGR*	
Field	Pages	%	Pages	%	Pages	%
Geodesy	51	6.5	171	7.2	260	6.2
Seismology	37	4.7	107	4.5	213	5.1
Meteorology	101	12.9	177	7.4	450	10.7
Geomagnetism and Aeronomy	38	4.9	1237	51.9	2106	50.3
Oceanography	115	14.7	104	4.4	262	6.3
Volcanology, Geochemistry, and Petrology	56	7.2	164	6.9	192	4.6
Hydrology	345	44.0	326	13.7	430	10.5
Tectonophysics	40	5.1	95	4.0	265	6.3
TOTALS	783		2381		4178	

JGR, the oceanographic contribution stayed about the same in number of pages, 104, but dropped to only 4.4% of the total number of pages printed. In 1960, the number of pages devoted to oceanography in *JGR* more than doubled, being 262, but the percent of the total number of pages printed amounted to only 6.3%, or less than half the relative contribution in the old AGU *Transactions*.

Space papers increased the contribution for the Section of Geomagnetism and Aeronomy from 4.9% in the 1958 AGU *Transactions* to over 50% of the total in both the 1959 and 1960 *JGR*.

A questionnaire was sent out to a sample of 57 members of the Section of Oceanography, AGU, in order to get a general sample of opinion from members who at least had enough interest in the Union to submit papers to *JGR*, plus others who had not committed themselves verbally. Selection was made as follows.

1. Authors of oceanographic papers in *JGR* for last two years.
2. Individuals selected at random from membership list who had not expressed an oral opinion on the subject to Pritchard.

Results from return of 37 questionnaires (out of 57 initially sent out)

	Pct of returns
A. Major objections to present format of *JGR*	
1. None (or hardly any)	24
2. Too much material not of interest	57
3. Too big	14
4. Papers not clearly categorized	5
B. Relative to splitting *Journal* into two (or more) sections	
1. Favor split	54
2. Do not favor split	35
3. Undecided	11
C. Question of subject matter division if *Journal* were split	
1. Included oceanography with meteorology and hydrology	62
2. Included oceanography with meteorology but not with hydrology	8
3. Included oceanography with hydrology but not with meteorology	5
4. Included oceanography with outer space papers	19
D. On amount of space in *JRG* devoted to individual disciplines	
1. Upset with amount of space devoted to outer space	30
2. Upset with amount of space devoted to hydrology	11
E. On the question of limiting publication in *JGR* to papers bearing on two or more fields of geophysics	
1. Definitely favored	3
2. Definitely opposed	46
3. Opinion not clearly expressed	51

There does not appear to be an overwhelming majority in favor of splitting the *JGR*. Many of those who were opposed to any change in present policy expressed themselves strongly in favor of the *JGR*. On the other hand considering the fact that those who had already expressed themselves to Pritchard orally (many rather strongly) in opposition to the present form of *JGR* were purposely not sent the questionnaire, it appears that the majority of oceanographers are dissatisfied.

The questionnaires do not give an answer as to how this dissatisfaction can be eliminated. There was no general agreement among those who favored a split of *JGR* as to what subject division should be made.

Pacific Northwest Regional Meeting

A symposium on ground water was held in Portland, Oregon, on November 16 and 17, 1960. The following basic conclusions were reached.

The gap between theory and practical application must be closed, and efforts should be made to verify, in the field, the results of analytical and laboratory research. A step in this direction is a compilation of methods to derive answers to ground water problems. A bibliography on the literature of hydrology should be assembled and maintained, and standardized terminology should be cataloged, used and revised when necessary.

Well planned and coordinated expenditures for needed research, in contrast to 'crash programs' promote great financial savings. Much thought must be given to the concept of 'optimum yield of a dynamic ground water system'. The assembly also defined research needs in the fields of infiltration in the unsaturated zone, movement and storage of ground water, and the role of ground water in basin discharge.

Our total ground water resources (including undeveloped deeper waters) must be inventoried, and the present and future needs of the nation and individual communities should be defined and kept current.

Pacific Southwest Regional Meeting

The 1961 annual Pacific Southwest Regional Meeting was held at the University of California, Berkeley, on January 26–27. The general session featured talks on California water supply, by Harvey Banks; water quality problems, by P. H. McGauhey; irrigation research in Israel, by Harry F. Blaney, and physical methods in planetary research, by Samuel Silver. Forty papers were presented at six technical sessions, which included hydrology, oceanography, aeronomy, a joint session on hydrology and meteorology, and, for the first time, a session on space physics. Abstracts of these papers appeared in the April 1961 issue of the *Journal of Geophysical Research*.

At a luncheon meeting President Thomas F. Malone, then Vice President of AGU, and Waldo E. Smith, Executive Secretary, spoke on current problems of the AGU.

At the business session the Regional Committee appointed A. F. Pillsbury to be General Chairman, and Morris Neiburger to be Secretary for the next triennium.

For this annual meeting David K. Todd was General Chairman, and Henry W. Anderson was Program Chairman. Paul R. Day made the local arrangements.

Geophysical Society of Hawaii

At a meeting held at the University of Hawaii, Honolulu, on Thursday July 6, 1961, Zdenek Sekera, Professor of Meteorology at the University of California (Los Angeles) gave a talk on polarization of sky light and its use in the study of atmospheric turbidity.

No. 10, October 1960

Some remarks about the problem of the construction of triangulation networks, V. F. Pavlov, 6 pp.

The accuracy of the position of the A station determined repeatedly from measured distances and direction angles, V. N. Simonovich, 5 pp.

New working ephemerides for the Talcott method for latitudes from +30° to +65°, D. D. Polozhentsev, 4 pp.

Consideration of the effect of diurnal aberration in the method of equal altitudes, Yu. F. Veselov, 3 pp.

Complex brigades for reconnoitering triangulation points and for constructing geodetic towers, L. A. Kashin, 2 pp.

Some remarks on a type of bench mark, R. Ye. Vinokurov, 2 pp.

The protection of pipe bench marks from heaving and corrosion, N. Z. Shreyber, 2 pp.

Investigation of the accuracy of intersection on the SPR-2 stereoprojector, M. V. Abramova, K. N. Gertsenova, 9 pp.

Experience in the topographic interpretation of spectrozonal aerial photographs, Kh. Ya. Kolosov, 2 pp.

The use of departmental data to improve the characteristics of wells and springs, R. I. Vol'pe, 2 pp.

Accurate determination of the constants of a wire tachymeter, S. N. Marchenko, N. Kh. Sadilenko, 5 pp.

Rod for the KA-2 alidade, I. G. Kuts, 1 p.

Vernier rods with rectangular marks, L. V. Nikolayev, 2 pp.

Improving the method of scribing map compilations, N. F. Smozhenkov, N. V. Goryachkin, 6 pp.

Topographic surveys for determining mineral reserves, 5 pp.

Considerations concerning the planning of new instructions for geodetic work for geophysical prospecting, A. S. Kronrod, 7 pp.

The economic map of an oblast', Z. I. Martynova, 2 pp.

Concerning the article by K. S. Bryakov, N. N. Lebedev, 3 pp.

The present technology of preparing maps for publication in the USA, S. A. Salyayev, 8 pp.

A new method of contact photographic printing, A. L. Garkavi, 3 pp.

Electronic scanning method for color printing, A. N. Uspenskiy, 4 pp.

Boris Natanovich Rabinovich (Obituary), 2 pp.

Bibliography, 3 pp.

Report of the Committee of Tellers

James N. Jordan, *Chairman*

Two proposals were recently placed before the membership relating to changes in the Statutes. The Committee of Tellers met at the office of the American Geophysical Union at 15h 00m on July 27, 1961, to count the ballots concerning these changes. The assortment of ballots considered is shown at right.

The outcome with respect to the two proposals was as follows:

	For	*Against*
Proposal I (see this issue, p. 335, *Statutes and By Laws*)	2142	18
Proposal II (see this issue, p. 335, (*Membership*)	1803	352

Committee members present were James F. Lander, G. Edward Manger, and James N. Jordan.

Total ballots received		2208
Rejected ballots:		
Ballots from delinquent members	19	
Ballots from non-citizens of U. S.	13	
Ballots from student members	10	
Defective ballots (unmarked, or intent of voter not clear)	3	45
	—	—
Qualified ballots tabulated		2163

SPECIAL ANNOUNCEMENTS

• **DUES FOR 1962**—At the meeting of the Executive Committee October 22, 1960, the Committee adopted the report of a Special Committee on Dues and Subscription Rates (see page 85, March 1961 *Transactions*), increasing the dues from $10.00 a year to $13.00 a year. This modest increase is necessary in order to continue the many activities of the American Geophysical Union, and, in particular, the *Journal of Geophysical Research*. This publication (which is frequently acclaimed as the world's leading journal in geophysics and of which we may be justly proud) became the responsibility of the American Geophysical Union in 1959 and has been published with the aid of a substantial grant from the National Science Foundation. This grant will soon be exhausted, and while its residue, plus page charges, advertising, and increased membership all help to make the *Journal* self-supporting, additional aid through this increase in dues will be required to keep AGU in the black, and to cover increasing costs and the maintenance of our reserve against an annual budget of a third of a million dollars.

In announcing this matter in this way, the Executive Committee has requested that the attention of members be called to a few of the many direct returns to the individual for his dues.

First, he receives the *Journal of Geophysical Research*, some 4000 to 5000 pages of scientific and technological papers bearing on the full spectrum of geophysics in a very compact format which, in some other format, might well take at least one-third more pages.

He receives the quarterly *Transactions*, which includes the timely *IGY Bulletins* as well as articles on the development of geophysical research over its whole broad field.

On other publications, such as monographs, he has the advantage of notification of the availability of material at membership prepublication rates and of securing these books at a substantial membership discount after publication.

On our translation journals, namely the *Geophysics Series* of *Izvestiya* of the Academy of Science, USSR, and *Geodesy and Cartography* of the USSR (others to be initiated soon), he has the advantage of the membership discount.

And certainly not the least, through membership he identifies himself with a growing and vital scientific group which is interested in advancing all phases of the geophysical science at the national and international levels. In particular, through AGU, our members are associated with the International Union of Geodesy and Geophysics (IUGG) and the International Council of Scientific Unions (ICSU), thereby acquiring immediate access to the broad spectrum of international activities that have been so important to the advancement of our science.

We believe that the economy of our activities is reflected by the fact that even with this increase, our dues remain far below those of any other scientific societies rendering comparable services.

• **PACIFIC NORTHWEST REGIONAL MEETING**—The Pacific Northwest Regional Committee of AGU is planning a meeting in Portland, Oregon, October 31 and November 1, 1961. Send inquiries and suggestions to Program Chairman William Bullard, 570 Pittock Block, Portland, Oregon. The Portland Section of the American Meteorological Society will join in this meeting.

• **FIRST WESTERN NATIONAL MEETING**—The First Western National Meeting will be held on the campus of the University of California at Los Angeles, December 27-29, 1961. Each section will hold sessions; those who desire to present papers should submit the title and informative abstracts (not to exceed 200 words) to the appropriate Section Program Chairman (see below) before October 15.

It is the plan to publish abstracts in the *Journal of Geophysical Research*. They should be in proper form for the printer—typed, ribbon copy, double or triple spaced, headed by name and title in the following form:

> John Doe (U. S. Geological Survey, Washington 25, D. C.) *Rainfall and Minimum Flows.*

The Program Chairmen are:

Geodesy: John C. Harrison, Institute of Geophysics, UCLA, Los Angeles 24, Calif.

Seismology: Stewart Smith, Seismological Laboratory, California Institute of Technology, 220 North San Rafael Ave., Pasadena 2, Calif.

Metorology: Morris Neiburger, Department of Meteorology, UCLA, Los Angeles 24, Calif.

Geomagnetism and Aeronomy: Robert E. Holzer, Institute of Geophysics, UCLA, Los Angeles 24, Calif.

Oceanography: William V. Kielhorn, Lockheed Aircraft Corp., Burbank, Calif.

Volcanology, Geochemistry, and Petrology:. G. J. Wasserburg, Department of Geological Sciences, California Institute of Technology, Pasadena, Calif.

Hydrology: Arvi O. Waananen, U. S. Geological Survey, Water Resources Division, 345 Middlefield Road, Menlo Park, Calif.

Tectonophysics: D. T. Griggs, Institute of Geophysics, UCLA, Los Angeles 24, Calif.

Planetary Sciences Committee: E. H. Vestine, the Rand Corporation, 1700 Main Street, Santa Monica, Calif.

The Chairman of the Committee for the Western National Meeting is Joseph Kaplan, Department of Physics, UCLA, Los Angeles 24, and the Secretary is W. W. Kellogg, 14739 McKendree Ave., Pacific Palisades, Calif.; they are serving also in these capacities on the General Program Committee.

At least one joint session will be held with the American Physical Society, which is meeting also at this time and place. Problems of mutual concern will be discussed by a panel of invited distinguished speakers.

Housing facilities and meals will be available in the Residence Halls of the University; rooms with maid service are $4.00 per night for double occupancy, and $5.00 for single occupancy. Reservations should be made directly with UCLA Residence Halls Conference Coordinator, 582 Gayley Avenue, Los Angeles 24, Calif. State number of nights needed, and enclose $5.00 (check or money order) as a deposit.

A revised abstract, retyped, may be submitted up to ten days after the meeting, to the Program Chairmen or to the Editor, J. A. Peoples, Jr., Department of Geology, University of Kansas, Lawrence, Kansas. If an abstract is too long or otherwise in unacceptable form, only the author's name and title will be published.

- AGU TO COSPONSOR SYMPOSIA AT DENVER—Four symposia to be given at the meeting of the American Association for the Advancement of Science (AAAS) in Denver, December 26-31, will be cosponsored by AGU.

A symposium on Physics of the Upper Atmosphere, to be held December 28 (morning), will be sponsored also by Sections of Physics and of Astronomy of AAAS, the American Astronomical Society, and the American Meteorological Society.

A symposium on Geochemical Evolution—the First Five Billion Years, will be held in two sessions, the mornings on December 28 and 29, cosponsored also by the Sections of Chemistry and of Geology and Geography of AAAS. Speakers include G. R. Burbidge of Yerkes Observatory, Harold Urey of the University of California at La Jolla, Philip H. Abelson of the CIW Geophysical Laboratory, and A. E. J. Engel of the University of California at La Jolla.

Water and Climate is the subject of the third symposium to be held December 28 (morning), and also sponsored by Sections of Agriculture, Geology and Geography, Social and Economc Sciences, Engineering, and Industrial Science of the AAAS, and the American Meteorological Society. Speakers will include Walter O. Roberts of the National Center for Atmospheric Research at Boulder, Dwight B. Kline of the US Weather Bureau, John W. Harshbarger of the University of Arizona, and Frank J. Trelease of the University of Wyoming.

A symposium on Ground Water Geology in two sessions (December 26 and 27, afternoon) is being arranged by Theodore Walker of the University of Colorado under the sponsorship of the Section of Geology and Geography of the AAAS.

The program will be available early in December (at $2.50) from AAAS, 1515 Massachusetts Avenue, N.W., Washington 5, D. C. People who require lodging facilities should write to the AAAS Housing Bureau, 225 W. Colfax Avenue, Denver 2, Colo.

- PACIFIC SOUTHWEST REGIONAL MEETING—The annual Pacific Southwest Regional Meeting will be held at the University of Arizona, Tucson, January 31, February 1 and 2, 1962. During the first two days, sessions will be scheduled for the presentation of contributed and invited papers. The last day will be devoted to excursions to nearby research installations and projects of interest. Informative abstracts (200 words or less) should be addressed to General Meetings Chairman C. H. M. van Bavel, US Water Conservation Laboratory, Route 2, Box 816-A, Tempe, Arizona, by November 15, 1961.

- FORTY-THIRD ANNUAL MEETING OF THE AMERICAN GEOPHYSICAL UNION, APRIL 25-28, 1962—The dates for the Forty-third Annual Meeting of the AGU at Washington, D. C., are *April 25-28, 1962*, inclusive. *Please note that this is a change from the tentative dates announced on page 216 of the June issue.*

Sessions will be planned by each of the eight sections, as well as the Planning Committee on Planetary Sciences, and many joint sessions will be held. Details will be given in the December and March issues of the *Transactions*. It should be noted that titles and abstracts (not more than 200 words) for the Section of Hydrology should be sent to the Program Chairman not later than January 1, 1962, and for the Section of Meteorology by January 9, 1962. For other sections the deadline is February 1, 1962.

- IAH SYMPOSIUM ON LAND EROSION—The International Association of Hydrology will sponsor a Symposium on Land Erosion in Bari, Italy, during October 1962. Three general subject areas will form the basis of the Symposium: (1) cartographic description of effects and factors of soil erosion; use of aerial photography; (2) description of testing instruments; artificial sprinkling, soil humidity, measurement of bed load and suspended sediment, and kinetic energy of rain; and (3) optional subjects, particularly fluvial morphology, transport of solids, and soil erosion.

There will also be opportunities to visit experimental stations, and regions most subject to erosion, particularly the Apennines and Southern Italy.

Informative abstracts (not more than 250 words) of prospective contributors from the USA should be submitted not later than January 1, 1962, to M. Gordon Wolman (Chairman of the Committee on Erosion and Sedimentation of the AGU Section of Hydrology), Isaiah Bowman Dept. of Geography, Johns Hopkins University, Baltimore 18, Maryland. An anonymous screening committee will review the abstracts, and authors of papers tentatively accepted will be so notified. Authors will be asked to submit complete papers by April 1, 1962.

• IUGG 13TH GENERAL ASSEMBLY, 1963—Major committee appointments are being made in connection with the 13th General Assembly of the International Union of Geodesy and Geophysics, to be held at the University of California at Berkeley, August 18-31, 1963. Thomas F. Malone, President of AGU, will serve as General Chairman of the General Arrangements Committee. George P. Woollard, Vice President of AGU, is the Vice Chairman of the Committee; Lloyd V. Berkner, Past President of AGU, and Joseph Kaplan, Vice President of the IUGG, are Honorary Chairmen of that Committee. Joseph Kaplan has also been named as Chairman of the Finance Committee, and David K. Todd as Chairman of the Local Arrangements Committee.

Inquiries concerning the Assembly should be addressed to the American Geophysical Union, 1515 Massachusetts Avenue, N.W., Washington 5, D. C.

• BULLETIN OF VOLCANIC ERUPTIONS—At the XII General Assembly of IUGG, the Helsinki meeting, it was voted 'to establish a place for the prompt reporting of volcanic eruptions.' H. Kuno of Tokyo University was indicated to receive the reports, which are to appear in a quarterly *Bulletin of Volcanic Eruptions*. Publication of the first issue of this *Bulletin* has been announced for sometime in the Fall of this year. No charge or subscription fee is required, but distribution is limited to persons with special or official need for them. Citizens of the United States who want these *Bulletins* should send their requests to the American Geophysical Union, 1515 Massachusetts Ave., Washington 5, D. C. Citizens of other countries should write their National Committees.

It is requested that observations of volcanic activity for Hawaii be sent to G. A. Macdonald, University of Hawaii, Honolulu, and those for Alaska to Robert R. Coats, U. S. Geological Survey, Menlo Park, California.

•PREAMBLE TO THE STATUTES CHANGED: RANK OF FELLOW ESTABLISHED—In a recent mail ballot, members overwhelmingly voted to approve two propositions viz., revision of the Preamble to the Statutes of AGU and the establishment of the grade of Fellow (see pp. 335 and 356, this issue).

• GRANTS FOR ASIAN GEOPHYSICISTS—The American Geophysical Union has received a modest grant from the Asia Foundation for the purpose of encouraging closer relations between Asian and American geophysicists. The funds will be used (1) to enable Asian geophysicists to become members of the American Geophysical Union (membership includes subscription to each of its two regular serial publications, the *Journal of Geophysical Research,* and the *Transactions*) at nominal cost (the balance for those accepted under this grant is being drawn from the grant); (2) to enable libraries, universities, and research institutes in Asia which have heretofore been unable, to subscribe to publications of the Union at reduced rates; and (3) to supplement travel expenses for Asian geophysicists who are in the United States, and want to attend meetings of the Union.

Applicants under (1) and (3) must be at least at the graduate level, and may be citizens of Afghanistan, Burma, Cambodia, Ceylon, Hong Kong, India, Indonesia, Japan, Korea, Laos, Malaya, Okinawa, Pakistan, Philippines, Singapore, Taiwan, Thailand, and Viet Nam. Applicants under (1) must fill in the regular AGU application for membership form (to be found in the back part of most issues of *Transactions* and the *JGR*). An applicant under (3) should state also (a) academic position, (b) nature of stay in the United States, (c) the meeting he plans to attend, and (d) the sum necessary for transportation to, and living expenses at, the meeting, and the part thereof for which a grant is requested.

Inquiries and applications should be sent to American Geophysical Union, 1515 Massachusetts Ave., N.W., Washington 5, D. C.

NATIONAL ACADEMY OF SCIENCES

Number 49 · July 1961

IGY BULLETIN

A monthly survey of plans, activities and findings in geophysics—with emphasis on United States contributions to the International Geophysical Year International Geophysical Cooperation–1959, and similar international endeavors including the World Magnetic Survey, the Year of the Quiet Sun, the Indian Ocean Expedition, the Antarctic research program, and space exploration and research. Preparation and publication of the Bulletin *is supported by the National Science Foundation.*

Project Mercury

In accordance with the custom of making the results of the United States geophysics and space-research efforts available to scientists throughout the world, a conference was held in Washington, D. C., on June 6, 1961, to report fully on the Mercury suborbital manned space flight of May 5, 1961. The conference was held under the auspices of the National Aeronautics and Space Administration, with the cooperation of the National Institutes of Health and the National Academy of Sciences.

Published proceedings of the conference, entitled Results of the First U. S. Manned Suborbital Space Flight, *served as a basis for much of the following report.*

A major event in the United States program to achieve manned exploration of interplanetary space took place on the morning of May 5, 1961, with the successful suborbital flight of Astronaut Alan B. Shepard, Jr., in a Mercury Spacecraft. (The more-recent flight of Astronaut Grissom is summarized separately on page 20.)

Part of Project Mercury, the National

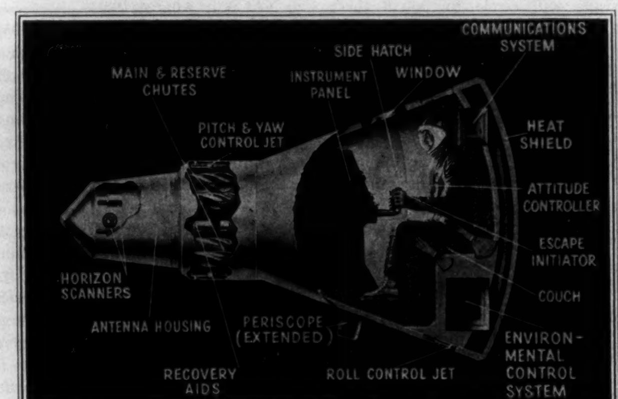
COMMUNICATIONS SYSTEM
SIDE HATCH
MAIN & RESERVE CHUTES
INSTRUMENT PANEL
WINDOW
PITCH & YAW CONTROL JET
HEAT SHIELD
ATTITUDE CONTROLLER
ESCAPE INITIATOR
HORIZON SCANNERS
COUCH
ANTENNA HOUSING
PERISCOPE (EXTENDED)
ENVIRONMENTAL CONTROL SYSTEM
RECOVERY AIDS
ROLL CONTROL JET

Fig. 1. Manned Mercury Spacecraft (with cutaway view of interior). NASA photograph.

Aeronautics and Space Administration's initial effort toward manned space exploration, the flight began at 9:34 am EST, when the space capsule with the astronaut aboard (Fig. 1) was launched from Cape Canaveral, Florida, by a modified Redstone rocket vehicle. Approximately 15 minutes later—after following a ballistic path (Fig. 2) carrying 302 statute miles downrange, reaching a peak altitude of 116½ statute miles above the earth, and achieving a maximum speed in excess of 5000 mph—the capsule and its occupant parachuted safely into the sea near the Bahama Islands, where they were recovered by a US Marine Corps helicopter of the Mercury Recovery Forces.

Astronaut Shepard bore the flight's stresses with no ill effects, maintained voice communication with the ground throughout the flight, and performed manual tasks involving control of the capsule prior to and during re-entry into the earth's denser atmosphere.

Project Mercury is a national effort of the United States, and is administered by the NASA Space Task Group, at Hampton, Virginia. Practical objectives are (1) to put a manned space capsule into orbit—the orbital capsule will circle the earth three times at altitudes between 100 and 150 miles and at speeds exceeding 17,000 mph in a flight lasting approximately 4½ hours; (2) to investigate man's ability to survive and function in a true space environment; and (3) to recover the capsule and the man safely. A possible extension, in the near future, of the manned-space-flight effort begun with Project Mercury may be an 18-revolution orbital flight lasting about 27 hours.

The primary objectives of the Mercury-Redstone ballistic test flight (designated MR-3) of May 5, 1961, carrying Astronaut Shepard, included (i) familiarizing a man with a brief but complete space-flight experience—lift-off, powered flight, weightless flight, re-entry into the heavier atmosphere, and landing; (ii) evaluating man's ability to perform useful space-flight functions—i.e., manual control of the spacecraft attitude before, during, and after firing of the retro-rockets that slow the capsule for re-entry, and maintaining voice communication with the ground; and (iii) studying man's physiological reactions during space flight. Added to these were the general objectives of continued testing of the Mercury spacecraft and its numerous systems, and of providing training for ground support and recovery forces.

History of Project Mercury

During 1956-58, NACA (the National Advisory Committee for Aeronautics, predecessor of NASA) and the military services conducted studies of the possible use of ballistic rocket boosters to provide the necessary velocities and altitudes for manned orbital and space flight. A NACA working committee concluded in March 1958 that ballistic-entry vehicles launched with existing long-range rockets should be used for the first manned US satellite, and details of a vehicle were drafted. Primary responsibility for research and development of a manned satellite program was assigned to NACA in August 1958.

In September and October 1958, the Joint Manned-Satellite Panel, established by NACA and the Advanced Research Projects Agency (ARPA) of the Department of Defense, formulated specific plans for a program of research leading to manned space flight. These plans were approved in early October 1958 by the Administrator of NASA, which superseded NACA as of October 1, 1958, and by the Director of ARPA. The NASA Space Task Group, composed of personnel from the NASA Langley (Virginia) and Lewis (Ohio) laboratories, and directed by Robert R. Gilruth, immediately began research on Project Mercury at the Langley Research Center.

Since its inception, Project Mercury has involved a wide variety of ground and flight tests, engineering problems, and operational

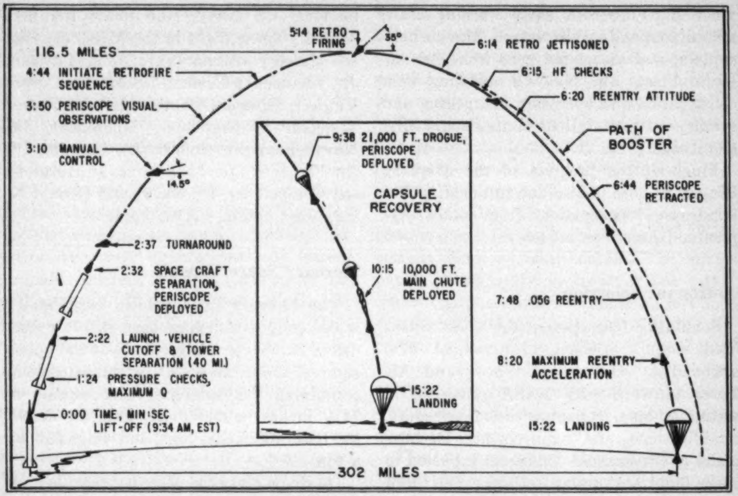
116.5 MILES
5:14 RETRO-FIRING
38°
6:14 RETRO JETTISONED
4:44 INITIATE RETROFIRE SEQUENCE
6:15 HF CHECKS
6:20 REENTRY ATTITUDE
3:50 PERISCOPE VISUAL OBSERVATIONS
PATH OF BOOSTER
3:10 MANUAL CONTROL
14.5°
9:38 21,000 FT., DROGUE, PERISCOPE DEPLOYED
CAPSULE RECOVERY
6:44 PERISCOPE RETRACTED
2:37 TURNAROUND
2:32 SPACE CRAFT SEPARATION, PERISCOPE DEPLOYED
10:15 10,000 FT. MAIN CHUTE DEPLOYED
7:48 .056 REENTRY
2:22 LAUNCH VEHICLE CUTOFF & TOWER SEPARATION (40 MI.)
8:20 MAXIMUM REENTRY ACCELERATION
1:24 PRESSURE CHECKS, MAXIMUM Q
15:22 LANDING
0:00 TIME, MIN:SEC LIFT-OFF (9:34 AM, EST)
15:22 LANDING
302 MILES

Fig. 2. Trajectory and Flight Profile of MR-3 Flight Carrying Astronaut Alan B. Shepard, Jr. Inset shows deployment of drogue and main parachutes. Relation of event times to points along flight path is only approximate. Adapted from NASA diagrams.

planning. There have been hundreds of wind-tunnel and aircraft drop tests; ten major rocket launches have been made; and specially modified rocket boosters have been put into production. The Mercury spacecraft, contracted to McDonnell Aircraft Corporation, has gone through the entire process of design, engineering, production, and test, and 12 capsules have been completed and delivered. Seven astronauts were chosen for the project after an intensive and stringent selection process; the astronauts and the operating forces have been trained, and a worldwide network of communications and tracking stations is in the final phase of construction.

Extensive support for Mercury has been given by the Department of Defense. From the large military pool of experienced aeronautical-engineering test pilots, NASA selected its seven astronauts. The Army, Navy, and Air Force are supplying valuable medical services and supporting personnel. Each of the Services is providing communications and tracking equipment as well as facilities for sections of the Mercury network.

The Air Force Space Systems Command also supplies Atlas rocket boosters and launch services, air rescue units, map-making and charting, aircraft for astronaut flight and zero-G (weightlessness) training, use of the Atlantic Missile Range, and animal specimens for the space-flight test program.

The Army is furnishing a tracking base at its White Sands Missile Range and amphibious vehicles for recovery needs near the launch site. The Redstone rocket, originally developed by the Army and now produced by NASA and private industry, is the prime launcher for Mercury suborbital flights, such as the MR-3 test.

The Navy, whose main responsibility is location, recovery, and delivery of the capsule and astronaut following flight, provides ships, aircraft, early warning craft, amphibious and service vessels, Marine helicopters, and associated gear from the Atlantic Fleet. The Navy is assisting with construction and operation of tracking and communications stations on its Pacific Missile Range.

Much of the progress of the Mercury Project to date is also due to the efforts of hundreds of contractors from many segments of American industry.

Astronaut Selection

Soon after formation of the NASA Space Task Group, aeromedical personnel were assigned by the Army, Navy, and Air Force to work with NASA personnel in setting up an astronaut selection procedure, qualifications, and requirements. Because many of the unusual conditions expected in space flight are similar to those experienced by military test pilots, NASA went to this field for volunteers for the astronaut program.

The general requirements were: possession of a bachelor's degree or the equivalent in engineering or the physical sciences; graduation from a military test-pilot school; 1500 hours of jet flying time; under age 40; and five feet, 11 inches, or less, in height. The educational requirement was included because a great variety of scientific and technical problems were expected to confront the astronauts throughout the program.

Of an initial group of 110 potential astronauts, about 90 volunteered for the program. A careful screening based on motivation, experience, and technical background left 32 for further, more-intensive screening. Exacting physical tests and careful assessment for psychological and stress tolerance resulted in final selection of seven Mercury astronauts to undergo preparation for space flight. They entered a training program at the Langley Research Center in early April 1959.

In addition to Alan B. Shepard, Jr., Commander, US Navy, who made the first Mercury space flight in the MR-3 capsule, the Mercury astronauts are: John H. Glenn, Jr., Lieutenant Colonel, US Marine Corps; Virgil I. Grissom, Captain, US Air Force; Malcolm S. Carpenter, Lieutenant, US Navy; Leroy G. Cooper, Jr., Captain, US Air Force; Walter M. Schirra, Jr., Lieutenant Commander, US Navy; and Donald K. Slayton, Captain, US Air Force.

Mercury Space Capsule

The Mercury space vehicle (see Fig. 1) is basically a truncated cone with a cylindrical parachute compartment at the upper end and above this a smaller truncated cone containing the antennas. The capsule is 74½ inches in maximum diameter across the base, 108 inches high, and weighs about a ton.

Its shape gives the Mercury capsule high aerodynamic drag, to slow it rapidly on re-entry, and static stability during portions of its flight path within the atmosphere. It is designed with an extremely blunt leading face covered with a heat shield, permitting it to withstand any known combination of acceleration, heat loads, and aerodynamic forces of launch or re-entry. The heat shield used for ballistic flights such as MR-3 is made of beryllium, and the shield for the higher-velocity, orbital flights is made of ablating fiberglass.

Pilot's Couch and Position in Vehicle: Each astronaut has a couch contoured to his specific body shape. The couches are constructed of crushable honeycomb material bonded to a fiberglass shell and lined with rubber padding. They are designed to support the pilot's body loads during all phases of the flight.

The position of the astronaut in the capsule—with back and lower legs parallel to the base and thus perpendicular to the direction of motion during acceleration and deceleration—minimizes the effects of G-forces on the body, and in particular on the circulatory system. In other body positions, great hydrostatic pressures during powered flight and re-entry would deprive the brain of blood or force excessive amounts into it, possibly causing serious damage. (One G is equivalent to the acceleration due to gravity at sea level and represents a force on a body equal to the sea-level weight of the body.)

Environmental Control: The environmental control system consists of two individual circuits—the cabin circuit and the astronaut's suit circuit—both of which normally operate for about 28 hours, simultaneously. The suit circuit can be isolated from the cabin circuit when the astronaut closes the faceplate of his helmet. Unless a failure in the cabin circuit causes loss of pressure, however, the pilot's pressure suit will not be inflated.

Plans called for cabin temperature to be held between 80° F and 100° F, and in the MR-3 flight it ranged from 93° F to 111° F, the latter during re-entry heating. Shepard's suit temperature rose from 71° F at launch to 90° F at landing. The spacecraft cabin and the astronaut's pressure suit are provided with a 100% oxygen environment to furnish breathing, ventilation, and pressurization gas required during the flight. The system is completely automatic, but in an emergency, manual controls can be used by the astronaut.

Instruments: The Mercury spacecraft contains a main instrument panel, a left console, and a right console. The main panel, immediately in front of the pilot, has navigational instruments in its left and center sections; the periscope is located directly in the center, affording maximum ease of viewing. Making up the right-hand section are environmental- and communication-system indicators and controls, and electrical switches.

The left console includes sequencing telelights and warning panel, indicators and controls for the spacecraft's automatic pilot,

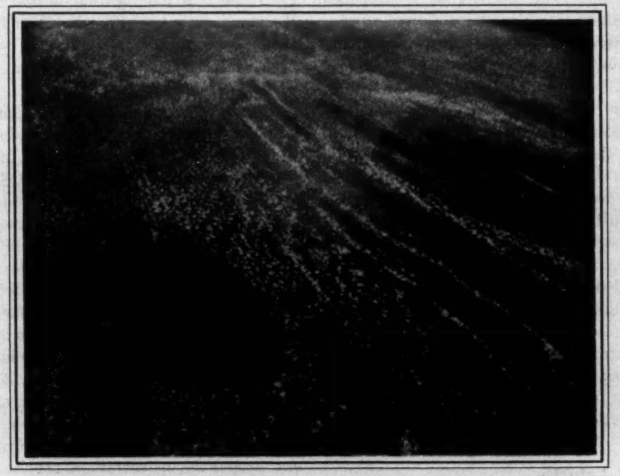

Fig. 3. View from MR-3 Spacecraft Near Peak of Trajectory. Astronaut's periscope view was similar to photograph, which looks northward toward Cape Hatteras and shows cloud cover over coastal regions of Southeast United States. Shepard was able to identify Lake Okeechobee, Florida; Andros Island, in the Bahamas; and some reefs. NASA photograph.

environmental control, and landing systems.

The earth periscope provides a 360° view of the horizon, and the pilot may adjust it manually for low or high magnification. On "low," he has a view of the earth about 1600 miles in diameter (Figure 3 is a photograph from the capsule corresponding to the periscope view seen by Shepard near the peak of the MR-3 flight); on "high," the field of view is reduced to about 80 miles across. The periscope also serves as a navigational aid, and altitudes can be measured by it to within ±10 nautical miles.

A 16-mm camera to the left of the astronaut's head photographs the instrument panel from launch through recovery, and another camera mounted in the main instrument panel observes the pilot throughout the flight.

Pilot communication with the ground is effected by high- and ultra-high-frequency radios and, if needed, a command receiver and telegraph-type code key. The main battery system consists of three 3000-watt-hour batteries and one 1500-watt-hour battery connected in parallel, sufficient to provide power for the entire MR-3 mission and a 16-hour post-landing period, if necessary. A standby power system of 1500-watt-hour capacity provides backup.

The clock in the spacecraft shows both elapsed-time and "seconds from launch," and has a time-delay relay that initiates the retro-rocket firing sequence. The capsule also has a barometer altimeter with a range from sea level to 100,000 feet; reference marks on the dial face indicate altitudes of deployment of the drogue (21,000 feet) and main parachutes (10,000 feet).

The pilot's physical condition is monitored throughout the flight; respiration rate and depth, electrocardiogram, and body temperature information are telemetered to flight surgeons on the ground.

Launch Vehicles

Since various segments of the Mercury operations could be tested by either smaller or larger boosters, depending on the specific need, three basic vehicles of different range and capability were chosen—the Little Joe, the Redstone, and the Atlas.

The *Little Joe* is made up of a cluster of eight solid-propellant rockets housed in a cylindrical section. Developing a total thrust of about 250,000 lbs at launch, it can propel a full-scale Mercury capsule at speeds up to about 4000 mph over ranges to about 130 miles.

The Little Joe has been used primarily in tests of the escape system and of capsule-booster matching. Six successful Little Joe launches have been made in tests covering a variety of altitude and velocity conditions. Early launches involved "boilerplate" versions of the capsule; later launches used actual capsules, and rhesus monkeys were carried on two flights.

The *Redstone* vehicle was intended for use in higher and longer-range ballistic qualification tests and in the first astronaut-piloted suborbital flights. The Mercury-Redstone is a modification of the reliable Redstone rocket of the U. S. Army, an earlier version of which put into orbit the first United States artificial earth satellite —Explorer I.

Standing 83 feet high and weighing 66,000 lbs, the rocket generates a thrust of 78,000 lbs and can propel the Mercury capsule at speeds greater than 5000 mph. In an earlier test, a Redstone-boosted capsule carried a chimpanzee passenger ("Ham") to an altitude of over 155 miles and a distance of nearly 420 miles downrange. It is planned to follow the Redstone-boosted flight of Astronaut Shepard with further manned Mercury-Redstone ballistic flights before orbital flight is attempted.

The *Atlas,* the largest Mercury booster, is intended for the final goal of manned orbital flight. The Atlas is capable of developing about 380,000 pounds of thrust and can propel the spacecraft at orbital speeds of over 17,000 mph and to apogee altitudes up to about 150 miles.

One successful Mercury test launch has

been made using the Atlas booster. In this test of the effect on the capsule of maximum heating at high re-entry speeds, the capsule reached a peak altitude of about 107 miles and a maximum velocity of approximately 13,000 mph.

Escape System

The possibility of an unplanned, emergency termination, or "abort," of the Mercury flight mission was provided for by inclusion of an escape rocket mounted on a tower above the spacecraft (Fig. 4). The escape system can be triggered by either automatic or manual means. In addition, an elevating boom, known as the "cherry picker," can remove the pilot from the capsule if an emergency arises during the final 90 minutes of countdown.

Once the launch vehicle has received its firing signal, and before it has lifted off the pad, automatic failure-detecting systems built into the vehicle would sense any impending trouble and initiate an abort. When this happens, the spacecraft is released from the launch vehicle and the escape rocket is fired, pulling the capsule to an altitude of over 2000 feet and well to one side of the launching pad. As the spacecraft reaches peak altitude, another small rocket, mounted beneath the escape rocket, carries the escape rocket and tower away from the spacecraft to clear the way for deployment of the craft's parachutes.

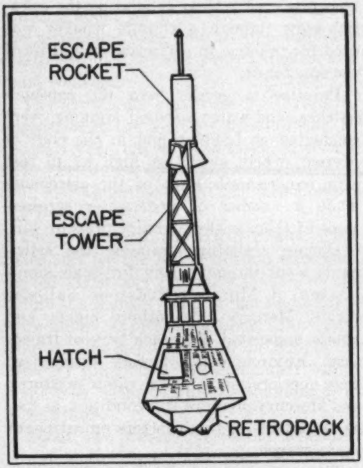

Fig. 4. Escape Tower and Rocket Mounted Above Mercury Capsule. The retro-rockets are used to carry capsule away from launch vehicle in "aborts" occurring during interval between separation of escape system and cut-off of booster engines. NASA drawing.

The six-foot drogue parachute opens first, stopping any oscillations of the capsule, pulling away the antenna canister, and deploying the 63-foot main landing parachute. The heat shield is then released, extending the landing-impact bag, which forms a pneumatic cushion to absorb the shock of landing. Though the impact bag is primarily for impacts on land, it is also required for water landings when wind and waves are high.

For impending booster malfunctions after lift-off and before normal separation of the escape system, the same sequence would be followed. In the interval between separation of the escape system and cut-off of the booster engine, the spacecraft can be separated from the booster automatically or manually by firing the posigrade rockets on the base of the craft.

The escape system can also be triggered, if necessary, by radio command from the blockhouse, by the Mercury Control Center, or by the range safety officer at the Central Control Building of the Atlantic Missile Range.

Training Program

The astronaut training program was broken down into six general areas, as follows:

(1) Education in the basic sciences—astronomy, meteorology, astrophysics, and geography, including techniques for making

scientific observations in these areas; in astronautics—particularly in various aspects of rocketry; in basic aviation medicine and orbital flight hygiene; and in the space environment.

(2) Familiarization with the conditions of space flight—heat, pressure, G-force levels, and other special conditions of space flight; this phase of training included periodic simulated flights in centrifuges and pressure chambers, weightless flying, training in human disorientation devices, and participation in the development of techniques to minimize the effects of vertigo. A major aim of this part of the training program was also to provide data on the astronauts' ability to contribute to system reliability under flight conditions; on psychological and physiological effects of both normal and emergency flight conditions; and on requirements for support and restraint, environmental control, and crew-space layout.

(3) Training in the operation and maintenance of the Mercury space capsule, with particular emphasis on scientific instruments and life-support equipment.

(4) Participation in the vehicle development program; to make use of the engineering backgrounds of the astronauts, and to familiarize them further with the project's technical aspects, each pilot has been assigned a specialty area in the Mercury development program, and thus acquires specialized knowledge that is shared with the entire group. The specialty areas are as follows:

Carpenter—Communications equipment and procedures, periscope operation, and navigational aids and procedures.

Cooper—Redstone booster, including configuration, trajectory, aerodynamics, countdown, and flight procedures.

Glenn—Cockpit layout and configuration, instrumenation, and controls for capsule and for simulation equipment.

Grissom—Reaction control system, hand controller, autopilot, and horizon scanners.

Schirra—Environmental control systems, pilot support and restraint, pressure suit, and aeromedical monitoring.

Shepard—Recovery systems and procedures, parachutes, and range network.

Slayton—Atlas booster and escape system, including Atlas configuration, trajectory, aerodynamics, countdown, and flight procedures.

(5) Aviation flight training; to maintain the astronauts' proficiency in high-performance aircraft, two jet fighter aircraft were assigned to them, and they receive annual instrument checks in jet trainers of the Tactical Air Command. This program provides the astronauts with additional altitude acclimatization, instrument flight training, and physiological conditioning for high-altitude, high-speed flight.

(6) Integration with ground-support and launch-crew operation, to give the astronauts complete knowledge of the launch phase of Mercury flights.

Among the many specific Mercury training activities was concentrated personal instruction in celestial navigation and star recognition; a trainer simulating the celestial view through a capsule window was used for practice in correcting yaw-drift of the spacecraft.

Practice in egress from the capsule's hatches, and water survival training, were conducted at Langley and in the Gulf of Mexico, where swells as high as 10 feet were experienced. Each of the astronauts made a number of underwater egresses, some of them in the Mercury pressure suit.

During centrifuge training, the astronauts went through many full-scale simulations of Mercury-Redstone ballistic flights, Mercury-Atlas orbital flights, and aborts associated with each type of trajectory. Environmental factors emphasized were acceleration, reduced cabin pressures, and Mercury pressure-suit condition, as well as the effects of these factors on astronaut performance.

The astronauts received familiarization with weightlessness by being flown through parabolic trajectories in aircraft. The weightless intervals varied from 15 seconds to a minute, and there were 3 to 24 such intervals per flight. Each astronaut experienced approximately 40 minutes of weightlessness in all. During these flights, data were collected on the astronauts' ability to perform a simple tracking task, on changes in normal speech, on experience in eating and drinking, on visual-acuity and visual-orientation problems of various body positions, and on post-weightless psychomotor testing.

Extensive training was received in the Air Lubricated Free Axis Trainer, using a periscope display or a window with a simulated earth horizon for controlling capsule attitudes, etc., during orbit and retro-rocket firing. The astronauts also received training in the multiple-axes space-test inertia facility at the NASA Lewis Research Center, for (i) familiarization with physiological and psychological effects of tumbling, and (ii) practice in recovery from tumbling when it occurs. A slow build-up of axes and rates was used, to a maximum of 30 rpm while rotating about all three axes. In all cases, the astronauts were able to stop tumbling relatively quickly using a rate indicator and hand controller.

The astronauts also have had extensive experience in the Mercury pressure suit. In the past year, almost all training in centrifuge, procedures, egress, environmental control, and weightless flight has incorporated the pressure suit.

Preparation for the MR-3 Flight: Pilot rehearsals for the MR-3 mission were conducted vigorously for more than a month before the launch, using actual flight hardware under realistic conditions. Many mission simulations were held in which the Mercury pilot "flew" his spacecraft within a specially designed altitude chamber or in a centrifuge.

About two weeks before the scheduled launch date, three days were devoted to conducting realistic countdowns and simulated flights at the launch site, with the pilot, in full-pressure suit, inside the spacecraft in the nose of the Redstone rocket. In the first two of these simulations, the gantry remained in position against the vehicle and the side hatch of the spacecraft was left open. In the third, the side hatch was secured, the pilot's cabin purged with oxygen, and the gantry moved away.

During the four days preceding launch, the MR-3 mission was rehearsed repeatedly, both in the vehicle itself and in a spacecraft simulator (the Mercury Procedures Trainer) in the Mercury Control Center.

Astronaut's Tasks during MR-3 Flight

To determine man's ability to function in space—the astronaut was given several definite tasks to perform during the flight. He also was expected to describe action he was taking, events as they unfolded, and what he saw during his control of the spacecraft. The following review of the MR-3 flight sequence (see Fig. 2) provides an outline of the astronaut's duties:

Thirty seconds after lift-off and at approximately equal intervals during powered flight, Shepard reported on his control-system fuel supply, the G-load he experienced, pitch angle of the capsule, cabin pressure, and his oxygen supply. (Figure 5 charts the G forces experienced during the flight.) He then monitored and reported cut-off of the booster engines and separation of the escape system, 2 minutes 22 seconds after launch and at an altitude of about 196,000

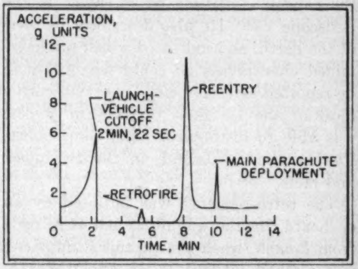

Fig. 5. Acceleration Profile of MR-3 flight. Magnitudes and times of G-force experienced by astronaut are shown. NASA diagram.

feet. At this time, the spacecraft had reached its maximum velocity of about 4500 mph with respect to the earth (ground speed) or 5180 mph relative to the solar system (inertial velocity).

About 2½ minutes after launch, a cluster of three small posigrade rockets was fired, pushing the capsule up and away from the booster. After oscillations generated by separation were corrected by the automatic pilot, the periscope was extended several inches into space. These events were reported by Shepard, and about 15 seconds after engine cut-off he announced the beginning of the spacecraft's automatically controlled 180° turn into its blunt-end-forward re-entry position.

Three minutes and 10 seconds from launch, the pilot manipulated the control stick, with his right hand, through a sequence of "dry run" yaw, pitch, and roll maneuvers. The results of this test of the pilot's ability to perform while weightless—a condition that lasted for 5 minutes and 4 seconds, through the highest portion of the trajectory—were simultaneously telemetered to the ground for analysis. Shepard then took actual control of the capsule's attitude, maneuvering it through up to 20° of pitch, yaw, and roll, in that order.

Almost 4 minutes from lift-off, and near peak altitude, Shepard began to use his periscope as a navigational aid, controlling the capsule's attitude by reference to the periscope view. He also described his view of the earth, and indicated which predetermined checkpoints he could see. Although he reported extensive cloud cover obscuring most of the US East Coast (Fig. 3), he was able to distinguish Lake Okeechobee, Florida, Andros Island, in the Bahamas, and reefs.

The retro-sequence was initiated by an on-board timer at 4 minutes and 44 seconds from launch, when the capsule's blunt end was pitched upward to an angle of 34°; yaw and roll were kept at 0°. Twenty-seven seconds later, at the peak of the trajectory, 116½ miles above sea level, three powerful solid-propellant rockets on the blunt face of the craft "ripple-fired," each burning for about 10 seconds at overlapping five-second intervals. During orbital flights, these rockets will be used to brake the much-greater speed of the craft as it comes back into the atmosphere. On the MR-3 suborbital training flight, however, they were fired only for continued qualification of the retro-motors and to provide the pilot with manual retro-fire control experience.

The pilot reported each retro-firing, and, 60 seconds after start of this sequence, he armed the "retro-jettison" switch to release the exhausted retro-rocket package. At 6 minutes and 20 seconds, in response to Shepard's manual control movements, the capsule went into re-entry attitude of 40° with respect to the horizon, and was then switched from manual to automatic control. The periscope was retracted at 6 minutes and 44 seconds.

The astronaut now once again put the capsule through manually controlled pitch, yaw, and roll maneuvers to determine whether he could function as well after more than five minutes of weightlessness as before. Some roll was planned in order to reduce landing dispersion during re-entry, and Shepard induced a roll of 2 rpm. As the craft touched the fringe of the atmosphere, 7 minutes and 48 seconds from lift-off, the astronaut felt the first re-entry G force of .05 G. The re-entry cycle lasted 1½ minutes, reaching a maximum force of 11 G's at 8 minutes 20 seconds (Fig. 5), and at an altitude of about 83,000 feet. During the re-entry cycle, forces greater than 5 G's were experienced for a full half minute.

At approximately 9½ minutes from launch and at an altitude of about 21,000 feet, the six-foot drogue parachute was deployed, and a little over ½ minute later, at 10,000 feet, the main parachute unfurled. The astronaut observed these operations through the periscope.

The capsule then descended at about 32 feet per second (roughly 20 mph) and landed on the sea surface at 9:49 am EST, 15 minutes and 22 seconds after lift-off. The impact point was within three miles of the previously calculated probable landing point, 80 miles ENE of Grand Bahama Island. The Redstone booster had already struck the water some 22 miles farther downrange.

Recovery Operations

Within five minutes of impact with the water, U. S. Marine helicopters had picked up Astronaut Shepard and his MR-3 spacecraft and were on the way back to their carrier, the *USS Lake Champlain*. The astronaut was landed on the ship's deck at approximately 10:00 am EST, 11 minutes after water impact.

To effect quick recovery of the astronaut and space craft in all Mercury flights, ships, aircraft, helicopters, and ground vehicles are stationed at (i) Cape Canaveral, to cover a possible abort while a booster is still on the launching pad, or just above it; (ii) in off-shore waters near Cape Canaveral, for an abort during early stages of a flight; (iii) in the expected landing area; and (iv) for suborbital flights, along the entire flight path to a region beyond the expected landing point.

Biomedical Results of MR-3 Flight

A major area of preparation for the MR-3 flight concerned the biomedical readiness of the astronaut and the testing of the life support systems. The biomedical preparation of the Mercury astronauts had two aspects: (1) an extensive course of instruction in the physiology of their body systems, to give the astronauts an understanding of the effects on them of flight stresses and to enable them to report better on these effects, and (2) a complete program of testing and training in the dynamics of the flight, with repetitive experiences under simulated flight conditions.

While the astronaut training program was progressing, a parallel program using animals for qualification of the support system was begun and carried through. This program, reached its culmination with the MR-2 flight in January 1961 carrying the chimpanzee, Ham. The chimpanzee bore the flight stresses well and continued to perform on the psychomotor apparatus throughout, except during the above-nominal accelerations associated with firing of the escape tower and re-entry. As the flight profile of MR-2 exceeded that expected for MR-3, it was concluded that an astronaut could be carried safely on MR-3.

The astronaut was examined in detail both before and after the MR-3 flight, thus providing both a fitness test prior to launch and a basis for determining any significant changes resulting from stresses of the flight. Preflight physical examinations showed Astronaut Shepard to be relaxed, cheerful, and in good health, with all findings consistent with those of previous examinations. Psychiatric examination indicated he was alert and had abundant energy and enthusiasm. He discussed flight hazards realistically and, while he expressed slight apprehension, he dealt with them by repetitive consideration of ways to manage each possible eventuality. All thought was directed toward the flight and no disturbances of intellectual function were observed.

Psychiatric examinations on Grand Bahama Island several hours after lift-off produced the report that Shepard ". . . seemed quietly elated and offered no complaints," and that he ". . . felt calm and self-possessed." The following is an excerpt from another portion of the report: "He was more concerned about performing effectively than about external dangers. He reported moderate apprehension during the preflight period, which was consciously controlled by focusing his thoughts on technical details of his job. As a result, he felt very little anxiety during the immediate prelaunch period. After launch, he was preoccupied with his duties and felt concern only when he fell behind on one of his tasks. There were no unusual sensations regarding

Table 1. Measurements of Vital Physiological Elements of Astronaut Shepard Before and After MR-3 Flight

Vital Physiological Elements	Preflight −8 hr	Postflight	
		Shipboard	+3 hr
Body weight	169 lb 4 oz	167 lb 4 oz	166 lb 4 oz
Temperature, °F	99.0 (rectal)	100.2 (rectal)	98 (oral)
Pulse per min	68	100	76
Respiration per min	16		20
Blood pressure, mm Hg:			
Standing			102/74
Sitting	120/78	130/84	
Supine			100/76
Pulse per min:			
Before exercise	68		76
After exercise	100		112
Time for pulse to return to normal	2¾ min		3 min

weightlessness, isolation, or separation from the earth. Again, no abnormalities of thought or impairment of intellectual functions were noted."

Two post-flight medical examinations revealed no significant changes in the astronaut's condition as a result of the flight. Electrocardiogram, electroencephalogram, and chest X-rays were normal. A number of changes, all expectable and within normal ranges, were noted, however, in body weight, temperature, respiration rate, blood pressure, and pulse rate at rest and before and after exercise; these are shown in Table 1.

The astronaut maintained a pulse rate of about 80 beats per minute during the prelaunch countdown with brief rises to 90-95 during significant spacecraft checkout events. Respiration remained generally between 15 and 20 breaths per minute during this period. As shown in Figure 6, pulse rate rose to 108 about a half minute before lift-off, was 126 at lift-off, and reached a peak of 138 at the time of cut-off of the launch-vehicle engine and spacecraft separation. This rate was sustained for about 45 seconds. The pulse-rate was erratic during the weightless interval, falling to 108 just prior to re-entry. A second peak, of 132, occurred about 30 seconds after maximum re-entry acceleration, and during descent the rate fluctuated between 130 and 108. At loss of signal after impact, it was 111 beats per minute.

The astronaut's respiration rate reached a peak of 40 breaths per minute during the launch and powered phase of the flight (Fig. 6), and fell to 20 per minute near the end of the weightless period. It rose again during re-entry to a high of 30, and fluctuated between 20 and 25 breaths per minute during the descent. Electrocardiogram traces showed no significant abnormalities throughout the countdown and flight; deep body temperature varied from 99° at installation of the pilot into the spacecraft to 99.2° near the end of the flight.

A report by physicians of NASA's Aerospace Medical Branch concludes that: (1) physiological responses of the astronaut were consistent with intact conscious performance during all phases of the MR-3 flight; (2) physiological responses to five minutes of weightless flight (interrupted by 23 seconds of retro-fire) were uneventful; (3) acceleration-weightlessness transition periods produced physiological responses within the limits of intact function, and the relative change in pulse rate in going from weightlessness to re-entry acceleration was comparable to that in going from 1 G to re-

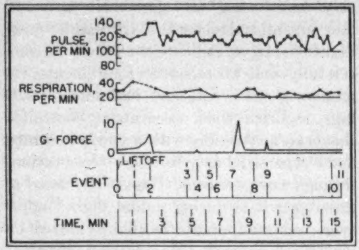

Fig. 6. Astronaut's Pulse and Respiration Variations during MR-3 Flight. Flight time, G-force profile, and major flight events are shown for comparison. Events are as follows: (1) maximum dynamic pressure; (2) launch-vehicle engine cut-off, spacecraft-booster separation, and spacecraft turnaround; (3) orientation to retro-fire attitude; (4) retro-fire; (5) jettison of retro-package; (6) orientation to re-entry attitude; (7) .05 G, at beginning of re-entry into denser atmosphere; (8) opening of drogue parachute; (9) opening of main parachute; (10) impact with water; and (11) loss of telemetry signal. NASA diagram.

entry acceleration on the centrifuge; and (4) special senses—vision, semicircular canal function, and hearing—appeared intact throughout the flight.

Pilot Performance during MR-3 Flight

Four major sources of data were used to evaluate Astronaut Shepard's performance capabilities during the MR-3 flight; they are (i) the astronaut's communications with the ground, (ii) records from the on-board pilot-observer camera, (iii) telemetry records of spacecraft attitude while under manual control, and (iv) the pilot's narrative of his activities as given in the post-flight debriefing.

During the flight, Shepard monitored 27 spacecraft events, communicated with the ground 78 times, made several series of attitude maneuvers, and made observations through the spacecraft periscope and window on several occasions. (See Figure 7)

Study of the pilot-observer-camera record showed that Shepard's attention appeared to have been focused on the appropriate monitoring instruments throughout the mission. His scan pattern was active and there appeared to be no wandering of attention, no fixation, and no illogical concentration on specific instrumentation. There was also no evidence of nystagmus (rapid, involuntary oscillation of the eyeballs).

Analysis of voice communication records indicated that the astronaut made all of the normal reports during launch and re-entry very close to the times of occurrence of the events, and comparisons with telemetered data verified the accuracy of these voice reports. In addition to the standard monitoring reports, Shepard made a number of unscheduled reports of unique events during the flight, responded rapidly to ground communications while weightless, and described clearly his observations through the periscope. The voice communications records confirm the camera observations that the pilot kept up with mission events and remained alert for novel or unprogrammed events throughout the MR-3 flight.

Because the flight path of a space vehicle is independent of attitude unless power is being applied, attitude control in space, except during retro-fire, is less critical than it is for aircraft. Thus, the expenditure of the additional fuel necessary to maintain control within tight limits is not justified.

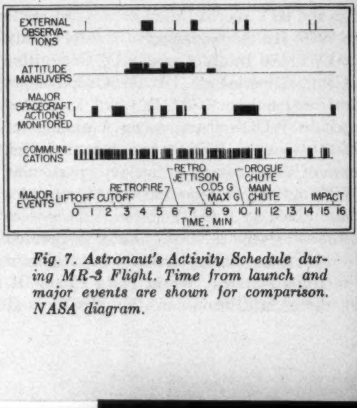

Fig. 7. Astronaut's Activity Schedule during MR-3 Flight. Time from launch and major events are shown for comparison. NASA diagram.

However, in each of the three attitude dimensions used—pitch, yaw, and roll—Shepard almost always kept the craft's attitude within the ranges established on trainer runs. During re-entry, when firing of the retro-rockets produces acceleration disturbances about the vehicle's axis, the pilot held the attitude fairly steady for all three axes of motion and reported that retro-fire misalignment torques felt about the same as in the preflight trainer.

In summary, records from the on-board camera, voice communications, and telemetry monitoring of spacecraft attitude, and substantiated by the astronaut's postflight narrative, indicate that the pilot successfully met all mission requirements. He monitored all events and instrument readings, reported them accurately, controlled the craft's attitude within normal limits, and reported clearly his observations through the periscope. His performance of these activities during actual flight, moreover, was comparable to that achieved on the procedures trainers operated under optimal environmental conditions.

International Exchange of Geophysical Data

As part of the fundamental international planning for the IGY program, World Data Centers were established to collect data from the numerous and wide-spread IGY observational programs and to make such data readily accessible to interested scientists and scholars for an indefinite period of time. In order to guard against accidental loss of irreplaceable data, and to make access as convenient as might be practical, it was agreed that there be duplicate centers for each IGY discipline in at least two, and for most disciplines, three, places in the world.

The original recommendation to establish the IGY World Data Centers was made in 1955. By the beginning of the IGY, July 1, 1957, the International IGY Committee (Comité Spécial de l'Année Géophysique Internationale, or "CSAGI") had designated specific WDC's from among a number of institutions or IGY national committees, each of which agreed to support a particular WDC actively in accordance with principles determined by CSAGI. Three WDC's were established: World Data Center A, divided by discipline among eleven institutions in the United States; World Data Center B, in three institutions in the USSR; and World Data Center C, in 21 institutions located in eight nations of Western Europe, in Australia, and in Japan.

The understandings regarding the content, mechanism, and schedule of data flow to Data Centers, as well as interchange among centers, were worked out under CSAGI auspices. These understandings were arrived at by specialists in each discipline after considerable analysis and discussion, both in international assemblies and in domestic meetings. The final agreements, which appear in the "Guide to World Data Centres," published in Volume VII of the *IGY Annals*, applied specifically to data taken during the IGY observation period, July 1957—December 1958. By subsequent resolution of CSAGI, they were also applied, with modifications in some disciplines and programs, to data taken during the observational period of "International Geophysical Cooperation—1959" (IGC-1959), January—December 1959.

Responsibilities and Methods of Operation

In addition to the detailed arrangements for data collection in the various disciplines, the WDC "Guide" set forth fundamental principles of operation of the WDC's. Each WDC is responsible for (1) endeavoring to collect a complete set of data in the field or discipline for which it is responsible, (2) safekeeping of the incoming data, (3) correct copying and reproduction of data, to maintain adequate standards of clarity and durability, (4) supplying copies to the other WDC's, as needed, and (5) preparing catalogues of all data in its charge.

The WDC's are also required to supply on request (at a cost not to exceed the cost of copying and postage) copies of material collected as part of the international data exchange, and also, by appropriate arrangements, to make this material in the WDC's available to visiting scientific workers. It was subsequently recommended that the WDC's collect reprints of publications on IGY subjects in order that the WDC's might serve as information centers; scientists were urged to cooperate in this endeavor by sending four reprints of all relevant papers to the appropriate WDC, from which they are then forwarded, as needed, to the corresponding WDC-A, B, or C.

Six-Monthly Catalogues: To make known to scientists the holdings of the WDC's and to facilitate interchange among the WDC's, the "Guide" required that catalogues of data in the WDC's be issued semiannually. Throughout the IGY, these catalogues were collated and distributed by the CSAGI Coordinator in Brussels; since 1959, catalogues have been distributed directly by the WDC's. WDC-A has thus prepared seven 6-monthly catalogues, the last four of which (for 1959 and 1960) were published in the WDC-A General Report Series. Each WDC-A catalogue is cumulative. The eighth 6-monthly catalogue (including data received by July 1, 1961) is now in preparation and will be available in August from WDC-A (National Academy of Sciences, 2101 Constitution Avenue, N.W., Washington 25, D. C.) or from any of the subcenters of WDC-A.

WDC-A Report Series: In keeping with the obligation of the WDC's to make data widely available, WDC-A has issued seven series of reports (see *Bulletin No. 44*) containing material of special interest. The General Report Series contains various reports of scientific results as well as catalogues and program descriptions. The remaining six series of reports are issued by the relevant discipline centers of WDC-A: aurora (instrumental), glaciology, oceanography, rockets, satellites, and solar activity. (A booklet entitled "List of IGY Report Series," containing a list of all reports issued by WDC-A, together with brief descriptions of the contents, is available upon request from IGY World Data Center A.)

Future Activities of the Centers

Following the termination of CSAGI, in 1959, responsibility for the World Data Centers was assumed by the Comité Internationale de Géophysique (CIG). The CIG reaffirmed the CSAGI resolution that the WDC's continue to collect data from observations made after the IGY/IGC period, and strongly recommended that data exchange arrangements be subject to periodic review.

The CIG Reporters were called upon to seek the advice of the relevant scientific unions in order to assure (i) that arrangements for future data interchange would be responsive to the changing needs and interests of scientific specialists and (ii) that a revised "Guide to WDC's" would be issued. In view of the formulation of plans for the Year of the Quiet Sun, 1964-65 (IQSY; see *Bulletin No. 48*), CIG recommended that the revised "Guide" be issued for 1960-63, and that another review be made for the IQSY period.

As for completion of the IGY/IGC data interchange: In January, 1961, the CIG resolved that IGY/IGC data collection be officially terminated by December 1, 1961, at which time the final catalogue of IGY/IGC data should be prepared for publication in the *IGY Annals*. CIG also called upon the appropriate CIG Reporters to evolve, with the help of international unions, the most suitable format for the final catalogue.

Geophysics Research Board's Panel on Data Exchange

The US National Academy of Sciences has established a Geophysics Research Board (see *Bulletin No. 48*) to serve as the national counterpart of the CIG; under the GRB, a Panel on International Exchange of Geophysical Data was established to make recommendations to GRB regarding data-exchange problems facing the CIG. At present, the Panel has three tasks: (i) completion of IGY/IGC data exchange; (ii) data exchange during the period 1960-63; (iii) data exchange during IQSY.

Although primary responsibility for the World data Centers lies with CIG, the CIG, in turn, and its US counterpart organization, the GRB, recognize the responsibility of other committees of the International Council of Scientific Unions (ICSU) in certain scientific areas, as follows: the Committee on Space Research (COSPAR), and the corresponding Space Science Board (SSB) of the US National Academy of Sciences; the Special Committee on Oceanographic Research (SCOR), and the Academy's Committee on Oceanography; and the Special Committee for Antarctic Research (SCAR), and the Academy's Committee on Polar Research. In evolving recommendations for future data exchange, the GRB's Panel on data exchange accordingly looks to these various US national committees and to the GRB Panels on the IQSY, the World Magnetic Survey, and the Upper Mantle Project, for recommendations in the relevant disciplines.

At the present time, the GRB's data-exchange Panel is conducting a review of data exchange arrangements for the current period. The Panel has made a survey of scientists in all geophysical disciplines in order to ensure that data collection requirements are reasonable and useful in the light of experience gained through the IGY and of rapidly changing interests in various scientific disciplines. In general, it is felt that the intensive data collection that characterized the IGY should be relaxed in order to relieve scientists of some of the burden of preparing data for the WDC's and to reflect the post-IGY decrease in observational efforts.

The Panel has also inquired of some 500 researchers who have used data from World Data Center A—many of them had consulted the archives of the Data Centers directly—to discover what research had been made possible by the availability of data in the WDC's, and what publications had resulted from these researches. The response to this inquiry indicates that a considerable number of important researches have been based almost solely on material in the WDC's, and a much larger number of published papers have been based in part at least on IGY data. At the same time, many of these researchers expressed doubt that the scientific community was generally aware of the wealth of information available in the WDC's.

The sentiment of the responses was quite unequivocally in favor of continued operation of the Data Centers, and many contained pertinent recommendations for future activities of the WDC's. In view of this response, the GRB has strongly recommended that the World Data Centers be continued in their present form at least until mid-1962, by which time precise national and international recommendations should have been formulated into a new "Guide" setting forth the activities and responsibilities of the World Data Centers in the coming years.

Antarctic Notes

NSF Office of Antarctic Programs

An Office of Antarctic Programs has been established within the National Science Foundation to replace the Antarctic Research Program, formerly a part of the Foundation's Office of Special International Programs.

Thomas O. Jones, who was NSF's Antarctic Program Director, has been appointed Head of the Office of Antarctic Programs and Albert P. Crary has been appointed Chief Scientist. Crary, who will also serve as Science Adviser on Antarctica to the Director of NSF, Alan T. Waterman, was Chief Scientist of the NSF Antarctic Research Program, and, prior to that, Deputy Chief Scientist of the US-IGY Antarctic Program.

The Office of Antarctic Programs has responsibility for the United States Antarctic Research Program (USARP), which includes all US scientific work in Antarctica. USARP scientists from colleges, universities, and Government agencies, working under NSF sponsorship, carry out research in biology, geodesy and cartography, geology, glaciology, meteorology, oceanography, upper-atmosphere physics, and seismology.

During the past 2½ years, the scope of scientific activity in the Antarctic has steadily increased. Many IGY investigations have been continued, particularly in meteorology and geophysics, and other fruitful fields of research have been encouraged. Extensive work is now being carried out on the geology of the continent and on the life forms found on the ice and in the surrounding oceans. Mapping activity has been greatly expanded, and oceanographic work in Antarctic waters has been increased. Beginning in the fall of 1961, the oceanographic research ship USNS *Eltanin*, operated by the Military Sea Transportation Service, will be used for NSF research programs in the oceans of the high southern latitudes.

New institutions have been brought into the work, and projects by individual investigators or teams working on specific problems have been encouraged. During the past year, for the first time, such projects received the largest proportion of the funds available for scientific work in Antarctica.

Major Antarctic research programs are maintained by the University of Wisconsin, the US Weather Bureau, Ohio State University, the US Geological Survey, Stanford University, the US Coast and Geodetic Survey, Bartol Research Foundation, the American Geographical Society, and the University of Michigan.

The Office of Antarctic Programs operates within a framework established by Bureau of the Budget Circular A-51, 1960, "Planning and conduct of the United States program for Antarctica." By that document, NSF was given responsibility to continue to exercise the principal coordinating and management role in developing and carrying out an integrated US scientific program for Antarctica. The Foundation, in consultation with the Department of State, also arranges for cooperative scientific programs with other nations participating in Antarctic research.

The Foundation looks to the Committee on Polar Research of the National Academy of Sciences-National Research Council for recommendations concerning proposed scientific programs in Antarctica. The United States Navy provides logistics support for scientific projects at US Antarctic stations.

Magnetic Declinations Obtained on Traverses in West Antarctica

In a letter to the *Journal of Geophysical Research,* April 1961, N. A. Ostenso and C. R. Bentley, of the Geophysical and Polar Research Center, University of Wisconsin, report on magnetic declinations in West Antarctica and on the Ross and Filchner

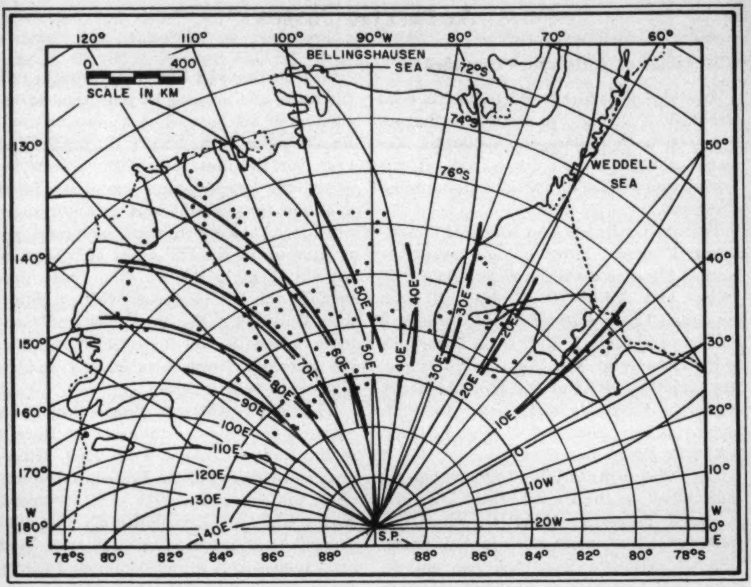
120°
110°
100°
90°W
80°
70°
60°
BELLINGSHAUSEN SEA
0
400
SCALE IN KM
72°S
74°S
76°S
WEDDELL SEA
130°
140°
150°
160°
170°
W 180° E
50°
40°
30°
20°
10°
W 0° E
50E
40E
30E
20E
70E
60E
50E
40E
30E
20E
10E
80E
90E
100E
110E
120E
130E
140E
0
10W
20W
S.P.
78°S
80°
82°
84°
86°
88°
88°
86°
84°
82°
80°
78°S

Fig. 8. Magnetic Declinations in West Antarctica. Light lines are isogonic lines from US Navy Hydrographic Office Map No. 1706S (1960); heavy lines are based on IGY traverse and station observations (dots). Redrawn from map by Ostenso and Bentley.

Ice Shelves. The declination observations were made during the course of six oversnow traverses and one airborne traverse conducted over the past four austral summers by US scientific teams.

Declination observations were made at intervals of 30-36 nautical miles on the oversnow traverses and at all stations of the airborne traverse, using either a Dietzgen transit or a tripod-mounted surveying compass. The magnetic azimuth of the center of the sun was compared with the true azimuth for the time of the measurement. The maximum error in absolute declination resulting from temporal magnetic variations is 1.0° for the transit observations and 1.5° for the surveying compass observations.

Figure 8 shows the locations of the observation stations, and contains isogonic lines (lines of equal magnetic declination) based on data obtained at these stations. Comparison of these isogonic lines resulting from field observations with computed isogonic lines from US Navy Hydrographic Office map 1706S (1960) shows a very close correlation. The small discrepancy may be partly explained by secular variations during the three-year period of observation, a higher-than-normal magnetic susceptibility in western West Antarctica owing to its largely volcanic composition, or both.

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Note on the MR-4 Suborbital Space Flight

The second Mercury manned suborbital test flight (MR-4), carrying Astronaut Virgil I. Grissom, was made successfully on July 21, 1961. Launched from Cape Canaveral, Florida, at 8:20 am EST, the space capsule followed approximately the same path as the MR-3 flight. Preliminary data from the 16-minute flight indicate that MR-4 reached a peak altitude of about 118 statute miles, a maximum inertial velocity of 5280 mph, and a distance downrange of 303 statute miles.

Several modifications were made in the spacecraft and in the astronaut's duties for the MR-4 flight. To improve visual observation, the two small portholes of earlier capsules were replaced by a trapezoidal window, 19 inches high, 11 inches across the base, and 7½ inches across the top, located directly above the astronaut's head; the new window provides a direct view of the horizon, thus permitting rapid determination of the capsule's attitude, and has reference lines to help the pilot maintain the correct angle for retro-fire. Also, instrument groupings were rearranged on the panel for easier reference; improvements were made in the manual control system to permit more rapid and precise attitude adjustment; and the escape hatch was fitted with explosive bolts for quick emergency egress. Finally, the astronaut was given fewer tasks than were performed during MR-3 to allow more time for observation.

The flight profile for the second manned Mercury flight was virtually the same as for the first. Astronaut Grissom performed his tasks well, maintained voice contact with the ground, and showed no ill effects of flight stresses. He reported by radio that the sky was black, and the sun very bright; a star, later identified as Capella, was also observed. The astronaut could see the southeastern coastline of the U. S. as far north as Cape Hatteras.

While the MR-4 flight itself was highly successful, the spacecraft was lost shortly after landing in the sea when the explosive bolts unexpectedly blew the hatch away; the capsule was flooded and sank in about 17,000 feet of water. Virtually all flight data were telemetered to the ground and are thus available for study, but the film record of the on-board camera was lost with the capsule. One of the recovery helicopters attached a line to the capsule, but the weight of the water inside made it impossible to lift the craft from the sea, and it was cut loose. Astronaut Grissom climbed from the capsule immediately after the hatch blew off and, after swimming several tens of feet in his pressure suit, was picked up by another helicopter. He was landed on the deck of the aircraft carrier USS *Randolph* a few minutes later.

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A monthly survey of plans, activities and findings in geophysics—with emphasis on United States contributions to the International Geophysical Year International Geophysical Cooperation–1959, and similar international endeavors including the World Magnetic Survey, the Year of the Quiet Sun, the Indian Ocean Expedition, the Antarctic research program, and space exploration and research. Preparation and publication of the Bulletin *is supported by the National Science Foundation.*

Project West Ford

The following material is based on four reports appearing in the Astronomical Journal, *66, No. 3, pp. 105–118, April 1961. Readers interested in further details of Project West Ford, and of orbiting dipole belts in general, may wish to consult this reference. Astronomers and geophysicists, in particular, may be interested in the opportunity to observe the dipole belt.*

In the autumn of 1959, the Lincoln Laboratory of the Massachusetts Institute of Technology informed the Space Science Board of the National Academy of Sciences of a proposal to place into orbit around the earth one or more belts of thin microwave dipoles to serve as an artificial scattering medium for radio signals in the centimeter band. Each dipole is a short length of metallic wire that will reflect radio waves. Laboratory studies of this technique suggest a potential capacity to transmit perhaps hundreds of thousands of "bits" of information per second over distances as great as one-third the way around the earth.

The Board was asked to consider the effects of such a communications system on the geophysical sciences, and especially to ascertain whether the first experimental test would limit or interfere with observations in any field of basic scientific research. The papers on which this report is based describe the proposed system and reflect the opinions of a number of astronomers asked to review its probable consequences. Since Project West Ford provides an opportunity to verify theoretical calculations by direct observation, astronomers with access to suitable equipment are urged to participate in these vital studies.

Design of Proposed Experiment

Figure 1 shows how two belts of orbiting dipoles might be used with highly di-

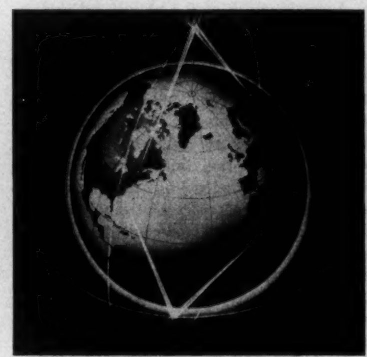


Fig. 1. *Schematic Representation of Dipole Belts in Polar and Equatorial Orbits. The manner in which such "orbital scatter" belts might relay radio messages between distant points is shown by the beams of highly directive microwave signals being reflected from the belts. (MIT drawing.)*

rectional microwave antennas to provide high-capacity communication circuits giving world-wide coverage. The following is a list of features of this technique that provide advantages over other satellite communication systems:

(1) The belts are relatively invulnerable to physical damage.
(2) No complex electronic equipment is required in space.
(3) Very large numbers of communications circuits can be provided by a single belt.
(4) Ground antennas are not required to track at high speed over large angles.

The design of the dipole system incorporates as far as possible certain desirable characteristics, including: (i) a maximum scattering cross section for radio waves per unit mass in orbit; (ii) small mass per dipole to minimize collision hazards; and (iii) an orbit high enough to make the dipole belt simultaneously visible over large areas, but at the same time having properties that would set a finite upper limit to the lifetime of the belt.

A combination of the above and certain other specifications leads to a choice of thin wire dipoles drawn from dense conducting metal (tin, copper, tungsten), with a maximum geometric area-to-mass ratio of about 50 cm^2/g. This area-to-mass ratio is low enough to minimize orbital perturbations caused by solar radiation pressure and micrometeorite collisions, but high enough to make a good reflector. The dipoles would be cut from wire 13 to 35 microns thick to a length of 1.77 cm, which is a half-wave resonant reflector for radio-frequency radiation of 8000 Mc/sec. Lower frequencies would require longer and hence more massive dipoles, thus increasing the collision hazard. Frequencies much higher than 8000 Mc/sec are subject to atmospheric and precipitation absorption effects.

For the test belt, 100 pounds of payload is available as a piggy-back arrangement on an already scheduled satellite. With this payload, approximately 75 pounds (35 kg) of dipoles could be dispersed at velocities ranging from 0.8 to 3.0 m/sec relative to the container, producing a cloud of dipoles spreading along the orbit in both directions. It is expected that it would take about 30 days for the belt to extend entirely around the earth, and that after 60 days the belt would be dispersed about 40 km in the radial direction and about 8 km perpendicular to the orbital plane. This estimate of the dispersion is based on predicted effects of the dispensing-velocity distribution and of differential orbital perturbations produced by solar radiation pressure, air drag, micrometeorites, and perhaps interaction between charged dipoles and the earth's magnetic field. Table 1 summarizes the relevant information.

Lifetime: It is important not to put objects or materials into relatively permanent orbits without prior assurance about possible harmful side effects. Therefore, the lifetime of the test belts becomes a matter of concern. At altitudes higher than 1000 km, atmospheric friction could not be depended on to bring the dipoles down, and, in general, solar radiation pressure produces variations in orbital eccentricity that are usually fairly small. However, such radiation-pressure variations can be quite large within a narrow range of altitude and orbital inclination where they become resonant with the period of precession of the major axis of the orbit. Within this narrow range

Table 1. Characteristics of West Ford Test Belt

Dipole resonance	8000 Mc
Dipole length	1.77 cm
Area-to-mass	50 cm^2/g
Belt altitude	A few thousand kilometers
Belt dimensions	8 × 40 km 60 days from launch
Mass of dipoles in belt	35 kg
Number of dipoles in belt	3.5×10^8
Average separation of dipoles	370 m
Density of dipoles	21 per km^3 60 days from launch

the periodic lowering of perigee might well limit the lifetime to one or two years; outside this range the belt lifetime might be one or two decades.

Another possible way of limiting the lifetime, currently under investigation, is to make the dipoles of white tin alloy, which disintegrates into gray tin powder under conditions in space. Solar radiation pressure may then bring the powder to earth.

Reflective Properties of the Orbiting Dipoles: A dipole reflects radiation most efficiently under the following circumstances: (i) when the wavelength (λ) of the incident radiation is twice the length of the dipole; (ii) when the wave front is parallel to the long dimension of the dipole; (iii) when the reflected wave front is also parallel to the dipole; and (iv) when the reflected ray is turned back 180° on the incident ray (i.e., back scattered).

Under the optimum circumstances listed above, the scattering cross section would be $0.89\ \lambda^2$, but the random orientation of the tumbling dipoles and departures from optimum polarization of the antennas would reduce it to about a tenth this value. The dipoles would also be quite resonant for integral multiples of the fundamental frequency. For still higher frequencies (in the far infrared), the length of the dipole is no longer critical. Finally, in near infrared and visible frequencies, where the wavelength of the radiation becomes shorter than the diameter of the wire, the reflection cross section levels off at its geometric value.

For longer wavelengths, i.e., for frequencies lower than the resonant frequency, the scattering cross section decreases as the fourth power of the frequency (Rayleigh scattering). The above discussion is summarized in Figure 2.

With these reflective properties in mind, it is possible to estimate the effects of orbiting dipole belts on astronomical measurements in the optical and photographic wavelength regions and on radio astronomy observations, and to determine the likelihood of interference with existing communication, navigation, or radar systems. The mass, shape, and distribution of the dipoles also determine the extent of the collision hazard.

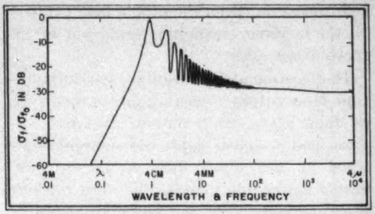


Fig. 2. *Scattering Cross Section (σ_f) of a Dipole as a Function of Wavelength or Frequency. The resonant frequency, f_o, which equals 1 on the normalized scale of the diagram, is 8000 Mc/sec. Cross-section scale gives the power re-radiated by a dipole, at frequency f, in terms of decibels (db) below the power at resonant frequency. (Curve for first four resonances adapted from MIT drawing, as published in* Astronomical Journal, *April 1961; high-frequency resonances are schematic.)*

Effects at Optical Wavelengths

Two principal properties of orbiting dipoles that might affect visual, photographic, or photoelectric observations in optical wavelengths have been considered: (i) the attenuation of light transmitted through the belt, and (ii) scattering of light by the dipoles, principally sunlight.

The maximum possible attenuation of transmitted light would be proportional to the product of the belt thickness, the density of dipoles per unit volume, and the average projected geometric cross section (see Table 1 for numerical data). Thus, maximum attenuation is: $40\ \text{km} \times 3 \times 10^{-2}\ \text{cm}^2/\text{km}^3 = 1.20\ \text{cm}^2/\text{km}^2$, or about 1 part in 10^{10}, a degree of attenuation not measurable by present techniques. It is also clear that light diffracted from the transmitted ray by the dipoles would not produce a detectable amount of scintillation, and that the starlight scattered from the dipole belt ($<10^{-10}$ $\times$ the incident starlight) would not be directly observable.

It appears, also, that during the nighttime observation of weak light sources, such as faint stars, very remote galaxies, airglow, and zodiacal light, the sunlight scattered by the dipole belt would be only barely detectable against the very darkest skies and using very sensitive equipment.

This scattered sunlight may be more readily detectable, however, from the orbiting observatories expected to be launched during the next several years to altitudes above the atmospheric airglow. The estimated flux at the earth's surface of sunlight illuminating the proposed test belt is equivalent to about 1.6 tenth-magnitude stars per square degree, assuming that a tenth-magnitude star is about 2×10^{-15} times as bright as the sun. Magnitudes of some natural sources of night-sky brightness, in terms of tenth-magnitude stars per square degree, may be considered for comparison. Zodiacal light ranges from 40 at the ecliptic poles to 300 in the ecliptic plane toward the direction of the sun. The light from unresolved stars varies from perhaps 10 near the poles of the Milky Way to 200 in the galactic equator. The airglow, darkest in the zenith and brightest near the horizon, contributes a roughly equal amount, but this is chiefly radiation that can be filtered out.

Even after diffusing for 60 days, the dipole belt would be only a few tenths of a degree wide as seen from the surface of the earth. The apparent angular motion of the belt resulting from the earth's rotation would carry it across the line of sight in less than half a minute at the zenith and in less than three minutes near the horizon. These short times, together with the very weak surface brightness of the belt, would obviously make the belt very difficult to observe with ordinary techniques.

In order to verify these conclusions, astronomers and other interested persons are being urged to make whatever photographic, visual, or photoelectric observations they can. There are several important possibilities. The growth of the cloud of dipoles with time may be followed by use of fast, wide-angle cameras and combinations of filters and emulsions that reject bright airglow radiations at wavelengths such as 3914, 5577, 6300, 6363 Angstroms, and others. For absolute-intensity information, photographs and photometric measurements should be calibrated against known standards, either laboratory light sources or astronomical objects such as the Andromeda galaxy, the Magellanic Clouds, and other previously well-measured bright surfaces.

Sensitive photoelectric photometers capable of detecting signal-to-noise ratios of the order of 10^{-2} would yield very valuable data on the growth and scattering properties of a dipole belt, especially if measurements were made in several colors or spectral regions. Polarimeter measurements with photoelectric equipment, or possibly even with the naked eye, would be especially useful in determining whether the dipoles in the belt have any tendency to assume a preferential alignment, through possible interaction with the earth's electromagnetic field or as a result of atmospheric drag.

In studies thus far, very little consideration has been devoted to what effects would arise if the solid-metal dipoles were to sublimate entirely. Some astronomers suspect that scattering effects and the bright line spectrum from metallic vapor might be more readily observable than the scattering of the continuous solar spectrum discussed in the foregoing paragraphs.

Effects on Radio Astronomy

Radio astronomy observations are carried out in wavelengths ranging from several meters down to less than one centimeter. Radio measurements may be affected by the orbiting dipole belts in three different ways: (i) by attenuation of radiation passing through the belt; (ii) by causing angle-of-arrival fluctuations, analogous to optical scintillation; (iii) by reflecting or scattering extraterrestrial radiation and terrestrial radio signals.

The attenuation effects would be greatest at the resonant frequency, corresponding to a wavelength of 4.0 cm. Sixty days after launch, it is estimated, the total scattering cross section of the dipole belts (i.e., the cross section per dipole of random orientation times the number of dipoles per cubic km along the line of sight) would be 32 cm^2/km^3. Thus, about one ten-millionth of the 4-cm radiation would be removed from a ray passing through the thickest part of the belt. The effects at other frequencies would be smaller, in proportion to the smaller scattering cross sections (see Fig. 2). The attenuation by the dipole belt is, in any case, negligible in comparison to the total attenuation along a vertical path through the troposphere, which is more than 10,000 times greater at 8000 Mc/sec than the belt attenuation.

It is estimated that the fluctuation in angle of arrival of radio waves passing through the dipole belt would be in the vicinity of one-millionth the angular width of the belt as seen from the ground. Again, this scintillation is negligible in comparison with that produced by natural phenomena.

As with attentuation and scintillation effects, which would probably not be detectable, it is estimated that radio-frequency radiation of natural origin (i.e., from the sun, moon, planets, radio stars, etc.) that is scattered by the orbiting dipoles would be several orders of magnitude below the sensitivity threshold of the best radio telescopes now in use. In reaching this conclusion, temperature of the earth and moon was assumed to be 300° Kelvin; the sun's temperature was assumed to be 10,000°K at a wavelength of 4 cm during quiet periods, and up to 1,000,000°K during periods of solar activity. The dipole belt, dispersed as it would be after 60 days, and as viewed from a distance of 4000 km, would raise the background temperature by about 4.7×10^{-6}°K on the average; somewhat higher peaks would oocur during times of solar activity, but they would still be much too weak to detect.

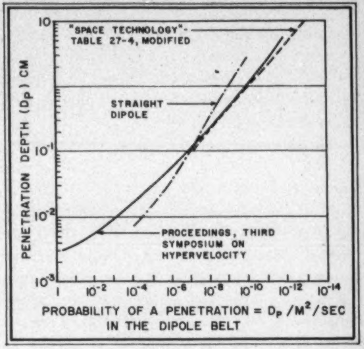


Fig. 3. *Probability of Penetration of a One-Square-Meter Surface Area to Various Depths, Dp, per Second of Exposure in the Dipole Belt. Also shown are similar curves for micrometeoroid penetration, based on data from the sources indicated. (Adapted from MIT drawing published in* Astronomical Journal, *April 1961.)*

The situation is altogether different, however, for the much stronger radio signals emitted by transmitters on the ground. The apparent "brightness temperature" of the scattering medium (T_M), which is a measure of the scattered power per unit bandwidth, is given by the relation $T_M = (\sigma/k\Delta\nu_R)(P_T\Delta_T/4\pi r^2)$, in which σ is the total scattering cross section; k is "Boltzmann's constant" (1.38×10^{-16} ergs/degree/particle), which can be regarded as a conversion factor to convert the average energy of moving charged particles to the temperature of the medium made up of the particles collectively; $\Delta\nu_R$ is the receiver bandwidth (assumed to be not wider than the transmitter bandwidth); P_T is the transmitter power; Δ_T is the effective area of the transmitter antenna; and $4\pi r^2$ is the area of a sphere whose radius, r, is the distance of the transmitter from the scattering medium.

According to this formula, the scattering medium will appear brighter if the scattering cross section, σ, is large; or if a large amount of radiation is channeled into a narrow bandwidth, $\Delta\nu_R$; or if the transmitted power, P_T, and the solid angle, $\Delta_T/4\pi r^2$, subtended by the radiation surface are large.

If 10 kw of power and a bandwidth of 10 Mc/sec are used, and if $r = 4000$ km and $\sigma = 4 \times 10^{-8}$, the brightness temperature of the medium, T_M, would be about 3° or 4° K. Thus, while the scattered radiation would be detectable but not yet serious under these conditions, it would become increasingly detectable with increase in the number of dipoles, with use of narrower bandwidths for line-radiation studies, or with use of larger numbers of higher-powered transmitters. It is necessary, therefore, that radio astronomers keep themselves informed concerning these factors.

Collision Hazards

The likelihood of damage arising from the collision of a space vehicle with a dipole has been estimated. Such an impact would cause the dipole to pentrate most deeply when the dipole and its velocity vector were aligned so that the dipole would pierce a flat surface perpendicularly. The depth of penetration (D_p) is given by the formula $D_p = L(\rho_d/\rho_s)^{1/2}$, where L is the dipole length, ρ_d the dipole density, and ρ_s the density of the space vehicle's surface material. The probability that a dipole would actually be aligned so as to achieve this maximum penetration, however, is extremely small (approximately one in one million).

The likelihood of a single penetration by a dipole to a specified depth within a one-square-meter area of the surface of a space vehicle is shown graphically in Figure 3. The curve is based on probabilities for various velocity vectors of the randomly oriented dipoles and on dispersion of the dipoles in the volume of space occupied by the test belt. Probabilities of penetration resulting from micrometeoroid collisions, based on initial data from the Explorer I satellite, are also shown.

Finally, bearing in mind that a satellite or rocket would spend only a very small fraction of its lifetime inside the dipole belt, it can be seen that the likelihood of a damaging collision with a dipole is quite minute.

Note:

Since the foregoing material was submitted for publication, the Space Science Board has prepared a summary report of its activities and findings regarding Project West Ford. This report, which includes the full text of a policy position announced by the United States Government on August 11, will appear in the September 1961 issue of the Bulletin. *In substance, the policy position states that no further launches of orbiting dipoles will be planned until the results of the West Ford experiments have been analyzed and evaluated, that decisions to place additional quantities of dipoles in orbit will be contingent upon this evaluation and the development of the necessary safeguards to protect space activities and any branch of science, and that astronomers throughout the world should be invited to cooperate in making measurements of the West Ford experiment.*

Mass Accumulation in West Antarctica

The following material was prepared by Mario B. Giovinetto, Institute of Polar Studies, Ohio State University.

The rate of mass accumulation is an important element in an understanding of the energy and mass budgets of the Antarctic ice sheet. For a particular location, the rate of snow-and-ice accumulation can be obtained through interpretation of the snow stratigraphy—the characteristic patterns developed in snow layers as a result of seasonal variations of the weather. These stratigraphic patterns can be traced horizontally in the upper layers of snow, and annual accumulation layers can be identified. (*Bulletin No. 23* contains an earlier report on Antarctic snow stratigraphy.)

Computations of the thickness and density of each annual accumulation layer at a location sampled permit an estimate of the net rate of accumulation in terms of the water equivalent of the snow and ice in the layers. Such values cannot generally be regarded as absolute, however, except for points where stratigraphic analysis is substantiated by direct measurements of accumulation (usually with stakes) or by geochemical analyses. Between substantiated points along a series of stratigraphic sample sites, values derived solely by interpretation of snow stratigraphy are assumed to represent the general trend of accumulation.

After accumulation values are obtained, a further step toward an understanding of the mass budget is to correlate these values with atmospheric circulation. Such a correlation may be relatively easy on the continental scale, but on the regional scale problems frequently emerge that require more-detailed study. At present, several investigations are under way concerning the relationship of snow accumulation to circulation patterns of both continental and regional extent.

Areas of Coverage and Sources of Data

This report is concerned primarily with accumulation in West Antarctica. During the last five austral summers, fifteen major US glaciological-seismological traverse parties, both oversnow and airborne, have gone into the field from Little America, Byrd, and Ellsworth IGY Stations, and from the Naval Air Facility at McMurdo Sound. (*Bulletin No. 39* contains a map showing the routes of most US traverses through the 1959–60 summer.)

Portions of the data collected in the field by V. Anderson on the Byrd Station Traverses of 1956-57 and 1957-58, by H. Neuberg on the Ellsworth Station Traverse of 1957-58 and the Marie Byrd Land Airborne Traverse of 1958-59, by W. Long on the Byrd Station Traverse of 1958-59, and by M. Giovinetto at Byrd and South Pole Stations and at Camp Michigan, near Little America Station, have been interpreted by Giovinetto for this report. (See Figure 4.) In addition, W. Boyd and A. Stuart have analyzed, and kindly made available, data they collected during the Ross Ice Shelf Traverse of 1957-58 and the Victoria Land Traverse of 1959-60, respectively.

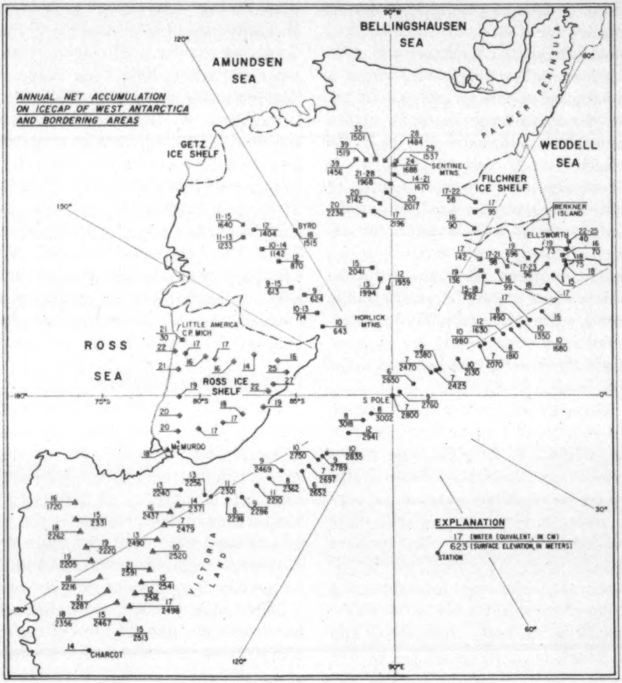
Because the route of the Commonwealth Trans-Antarctic Expedition, 1957-58, passed over parts of West Antarctica or came very close to its borders, accumulation values along this route, obtained and kindly made available by H. Lister, are also included.

Accumulation Values

The values of net annual accumulation shown in Figure 4 are based on analyses of approximately one-half the glaciological data available; with only a few exceptions, they are preliminary in nature. Average annual accumulation values for the individual stations were computed from analysis of three to eight consecutive annual layers, for periods beginning in 1950 or earlier.

Direct measurements were obtained with accumulation stakes at a few of the stations along routes over which the several series of stratigraphic studies were made. The stake measurements were obtained over periods of one to three years, and the annual accumulation values thus computed agree with related values determined from stratigraphic interpretations. For stations between these known points, accumulation trends are inferred.

The accumulation values shown in Figure 4 present a recognizable pattern. It can readily be seen that the region of largest annual accumulation in West Antarctica is the Bellingshausen Sea—Sentinel Mountains region. In the vicinity of the Sentinels, water-equivalent values of 24-29 cm/year were obtained, and current studies by M. J. Rubin and Giovinetto, of the relation between accumulation and atmospheric circulation, indicate that accumulation in the


ANNUAL NET ACCUMULATION ON ICECAP OF WEST ANTARCTICA AND BORDERING AREAS
AMUNDSEN SEA
BELLINGSHAUSEN SEA
WEDDELL SEA
ROSS SEA
PALMER PENINSULA
GETZ ICE SHELF
FILCHNER ICE SHELF
ROSS ICE SHELF
BERKNER ISLAND
ELLSWORTH
SENTINEL MTNS.
HORLICK MTNS.
BYRD
LITTLE AMERICA
C.P. MICH
McMURDO
S. POLE
CHARCOT
VICTORIA LAND
90°W
90°E
120°
150°
180°
150°
120°
60°
30°
0°
60°
75°S
80°S
85°S
EXPLANATION
17 (WATER EQUIVALENT, IN CM)
623 (SURFACE ELEVATION, IN METERS)
STATION
32 1501
39 1519
39 1456
28 1484
29 1537
24 1688
21-28 1968
14-21 1670
20 2142
20 2017
20 2236
17 2196
17-22 58
17 95
16 90
11-15 1640
12 1404
11-13 1233
18 1515
10-14 1142
12 870
9-15 613
9 624
10-13 714
10 643
15 2041
13 1994
12 1959
22-25 40
19 73
16 70
18 75
18
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19 696
17 142
17-21 98
17-23 96
19 136
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15-18 292
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Fig. 4. *Mass Accumulation on West Antarctic Icecap and Bordering Icecap Areas. Accumulation (upper figure for each station) is given in centimeters of water equivalent and represents the annual net value for the station. Elevation, in meters, is also shown for most stations (lower figure). Sites sampled by US teams during the 1956–57, 1957–58, 1958–59, and 1959–60 austral summers are indicated by squares, triangles, and diamonds, and their data were analyzed by M. B. Giovinetto, A. Stuart, and W. Boyd, respectively; sites sampled during the Commonwealth Trans-Antarctic Expedition, 1957–58, are circled, and their data were analyzed by H. Lister. Map prepared by Giovinetto.*

coastal belt just south of the Bellingshausen Sea may be as great as 60 cm/year, or greater. This may also be the region of greatest annual accumulation in all of Antarctica. (An earlier report, by R. L. Cameron and R. P. Goldthwait, 1960, suggests that greatest accumulation may occur in the coastal region between 5° E and 10° W, in East Antarctica.)

As indicated by the map, annual accumulation generally decreases toward the high interior plateau region, with the lowest values occurring along the route of the Commonwealth Trans-Antarctic Expedition. Values in the vicinity of the geographic South Pole are especially low, ranging from 6 cm/year, the minimum obtained from these data, to about 9 cm/year of water equivalent. Values comparable to this were also obtained in Victoria Land by Lister and Stuart on the basis of stratigraphic interpretations, but stake measurements by A. P. Crary in south Victoria Land and snow-stratigraphy studies along the route of the McMurdo-South Pole traverse, 1960-61, yielded still lower accumulation rates than those of Lister and Stuart.

A pronounced east-to-west decrease in accumulation in central West Antarctica can also be seen, falling from the high near the Sentinel Mountains and Bellingshausen Sea coast to lows of 9-15 cm/year near the eastern margin of the Ross Ice Shelf. Accumulation values on the ice shelf itself are about intermediate between the highest and lowest in West Antarctica, and values for both the Ross and Filchner ice shelves are approximately similar.

From the values presented here, the average accumulation in West Antarctica (excluding the Palmer Peninsula) is estimated to be 18 ± 2 cm/year.

Problems in Snow-Stratigraphy Interpretation in the Antarctic

Analyses of the original stratigraphic data have revealed certain factors that make some areas more difficult to interpret than others. In general, the difficulties of stratigraphic interpretation increase from the Weddell and Bellingshausen Sea coasts toward the Byrd and South Pole stations. The Ross Ice Shelf is relatively easier to interpret than the polar plateau of West Antarctica, and the most difficult area for stratigraphic interpretation is Victoria Land, in East Antarctica.

Interpretation in interior areas, and particularly in Victoria Land, is made difficult by two factors: (i) excessive sublimation resulting from large temperature differences between the upper snow layers and the air, causing a vertical mass transport within the snow that may obliterate some horizons entirely (see *Bulletin No. 23* for a more-detailed explanation of this process); and (ii) irregular distribution of the snow accumulating on the surface, resulting mostly from wind action. The latter effect is also strong in the vicinity of the South Pole.

At several localities in Victoria Land, layers of large, soft grains and crystals formed by sublimation effects were more than 50 cm thick. The frequency of occurrence of this phenomenon appears to increase from the margins of the Ross Ice Shelf toward the interior of East Antarctica, and an extreme development of it was seen at the easternmost station occupied by the 1958-59 Victoria Land Traverse party. At this station, at 78° 03′ S, 131° 43′ E, sublimation crystals made up 133 of the upper 166 cm of the snow strata.

Summary and Conclusions

Analyses of snow-stratigraphy and comparisons, at some points, with accumulation-stake data show patterns of mass accumulation for West Antarctica and bordering portions of East Antarctica. It is seen that accumulation generally decreases toward the higher interior areas, and it appears that the region of maximum accumulation is in the vicinity of the Bellingshausen Sea. Average accumulation in West Antarctica, excluding the Palmer Peninsula, is estimated to be about 18 cm/year.

Where corresponding measurements were available, accumulation values interpreted from snow stratigraphy were in general agreement with those obtained by measurements using stake networks. This general agreement between results of the two methods was found at virtually all permanent scientific stations, including the Ellsworth, Byrd, South Pole, and Little America (Camp Michigan) IGY stations and at NAF McMurdo. However, at Charcot Station (Fr.), stratigraphic interpretation yielded a value nearly twice that measured with stakes.

While accumulation values between the permanent stations are not yet substantiated, they are believed to represent the existing trends of geographic distribution of mass accumulation on the ice sheet of West Antarctica.

Explorer XI Gamma-Ray Satellite

Explorer XI (1961 Nu), carrying instrumentation to detect and measure in nearby space gamma radiation produced by galactic cosmic rays, was launched from Cape Canaveral, Florida, by the US National Aeronautics and Space Administration at 9:16 am EST (14:16.38 UT), April 27, 1961. Nine minutes later (14:25.35 UT) the satellite was injected into orbit at approximately 27°N, 66°W.

Orbital data a few weeks after launch were as follows: perigee, 490.8 km (305 statute miles); apogee, 1780.9 km (1106.6 statute miles); orbital inclination 28.8°; and period, 108.03 minutes. The experiment is expected to have a lifetime of about one year, and the satellite will probably remain in orbit for several years.

The satellite was boosted into orbit by a four-stage Juno II rocket, furnished by NASA's Marshall Space Flight Center, Huntsville, Alabama. The Juno II consists of a modified Jupiter first stage, developed originally by Marshall personnel, and three solid-propellant upper stages provided by the NASA Jet Propulsion Laboratory, Pasadena, California.

Immediately after it was certain that orbit had been achieved, the Space Science Board of the US National Academy of Sciences sent a telegram to the Committee on Space Research (COSPAR), in The Hague, providing orbital information and experimental details for transmission to all COSPAR participants. Data obtained during the course of the experiment will also be forwarded to COSPAR for dissemination to participants and will be deposited in the IGY World Data Centers.

Experimental Objectives

The primary objectives of the Explorer XI experiment are (i) to detect extra-terrestrial high-energy gamma rays, (ii) to map their distribution in terms of direction of arrival, and (iii) to relate these measurements to the cosmic-ray flux density and to the density of intersteller matter throughout our galaxy. Gamma rays in space are produced by the decay of electrically neutral pi-mesons, which are, in turn, produced by collisions between primary cosmic rays and atomic nuclei (possibly of interstellar hydrogen or dust). Thus, the Explorer XI experiment may provide new knowledge about the origin of primary cosmic rays.

Because they are electrically charged, the high-velocity protons making up the bulk of inflowing galactic cosmic rays are deflected by the earth's magnetic field, as well as by magnetic fields in space. Hence, it is difficult to determine their true direction of origin. The highly energetic gamma rays, however, are electromagnetic in nature—as are visible light, X-rays, and ultraviolet radiation—and bear no electrical charge. Since they are unaffected by magnetic fields, the gamma rays can provide an indirect measure of both intensity and direction of arrival of the primary cosmic rays from which they are derived.

Gamma rays are also produced in the earth's atmosphere by cosmic-ray protons that have already been deflected from their original paths by the geomagnetic field, and by protons from the Van Allen radiation belts. Moreover, gamma rays originating beyond the earth's atmosphere cannot generally be distinguished from those generated within the atmosphere. Therefore, in order to use this technique for study of galactic cosmic rays, an instrument platform of known orientation capable of measuring gamma radiation through a large area of space above the masking effects of the atmosphere was required. Explorer XI provides such a platform.

Description of Satellite

The Explorer XI payload is 88.8 inches long over-all, weighs a total of 95 pounds, and, along with the attached fourth-stage rocket, resembles an old-fashioned street lamp. (See Figure 5.) The 44.5-inch-long, 12.8-lb, burned-out fourth-stage rocket is included in the payload configuration to provide additional length and weight needed to maintain a tumbling motion of the satellite (see below); it also acts as part of the transmitting antenna. The gamma-ray "telescope" is contained within an octagonal aluminum box, 11 inches in diameter and 21 inches long, mounted on a 6 × 20.5-inch aluminum instrument column. In addition to housing the gamma-ray detector, the box provides four external surfaces for the satellite's solar cells.

As it travels along its orbit, Explorer XI tumbles end-over-end to enable the telescope, which is aimed outward from the end of the octagonal box, to scan as large a portion of surrounding space as possible. (See Figure 6.) The rate of tumbling varies somewhat, but initially it was about 5 revolutions per minute. A four-lb weight placed near the nozzle of the fourth-stage rocket also helps to achieve the ratio of moments of inertia along the transverse and longitudinal axes necessary to maintain the tumbling motion.

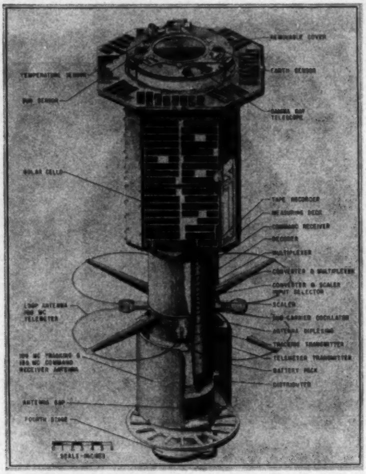
REMOVABLE COVER
TEMPERATURE SENSOR
EARTH SENSOR
SUN SENSOR
GAMMA RAY TELESCOPE
SOLAR CELLS
TAPE RECORDER
MEASURING DECK
COMMAND RECEIVER
DECODER
MULTIPLEXER
CONVERTER & MULTIPLEXER
CONVERTER & SCALER INPUT SELECTOR
LOOP ANTENNA 108 MC TELEMETER
SCALER
SUB-CARRIER OSCILLATOR
ANTENNA DIPLEXING
108 MC TRACKING & 108 MC COMMAND RECEIVER ANTENNA
TRACKING TRANSMITTER
TELEMETER TRANSMITTER
BATTERY PACK
DISTRIBUTER
ANTENNA GAP
FOURTH STAGE
SCALE-INCHES

Fig. 5. *Explorer XI Gamma-Ray-Astronomy Satellite (cutaway view) Showing Configuration and Instrumentation. NASA drawing.*

Instrumentation and Experimental Technique

The Explorer XI gamma-ray experiment is conducted under the direction of William Kraushaar and George Clark of the Massachusetts Institute of Technology, and the satellite's gamma-ray telescope was developed and built at MIT. The supporting electronic equipment for the experimental instrumentation, as well as the payload structure itself, were designed and built at NASA's Marshall Space Flight Center.

The gamma-ray telescope used in Explorer XI consists essentially of a combination of radiation detectors—a "sandwich" scintillation detector, a Cerenkov detector, and a plastic scintillator that serves as an anti-coincidence shield—together with circuitry capable of distinguishing between the different forms of radiation striking the detectors and screening out all but gamma radiation. The system is quite versatile, however, and, on command from the ground, the other types of radiation can also be observed. The telescope is designed to detect gamma rays with energies greater than about 70 million electron volts entering through an acceptance cone having a half-angle of about 15°. The instrument's axis of sensitivity rotates in the plane of the satellite's tumbling motion (see Fig. 6).

The sandwich detector consists of two layers of sodium iodide (NaI) sandwiched between three layers of cesium iodide (CsI). Each layer is 7.6 cm in diameter and 0.5 cm thick, and the whole assembly is optically coupled to a single phototube to detect light flashes in the sandwich stack. The electronic system produces two signals for every scintillation event in the sandwich detector—one, a fast signal, is proportional to the pulse amplitude from the NaI layers and the other is proportional to the total-pulse amplitude from all five layers.

The Cerenkov detector, situated behind the sandwich detector, has a cylindrical lucite radiator, 7.6 cm in both diameter and length, which is viewed from the back by two phototubes; this detector responds selectively to very-high-energy charged particles traveling from the direction of the sandwich detector. The shield, covering the solid angle in front and on the sides of the sandwich and Cerenkov detectors, is a plastic scintillator viewed by five phototubes.

An incoming gamma ray first passes through the shield, without causing a scintillation pulse since it is uncharged. Upon striking a nucleus in the sandwich of crystalline NaI and CsI layers, the gamma ray produces a positron and an electron. These, in turn, pass through the remaining layers, causing scintillation pulses, and continue out the back of the telescope through the Cerenkov detector, once again causing scintillation. Thus, to record the passage of a neutral particle, approximately coincident signals must be generated by both the sandwich and Cerenkov detectors, *unaccompanied* by a coincident pulse from the shield.

As neutrons generated locally by interactions of charged cosmic rays in the satellite structure can cause the same sequence of events as gamma rays, the telescope must also distinguish between these two types of neutral particles. This is done by differences in excitation, when struck by either gamma rays or neutrons, of the two types of materials used in the sandwich detector—NaI and CsI. These differences in excitation are indicated by differences in the fast and total pulses from the sandwich detector. Gamma rays cause approximately equal excitation in the two materials, while neu-

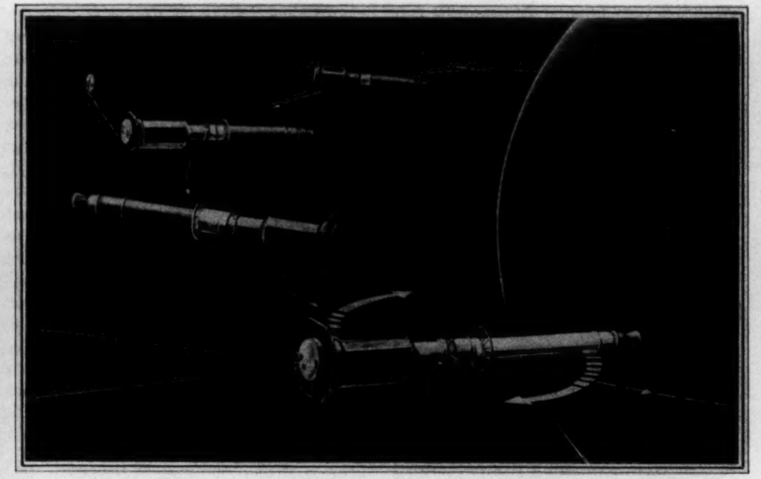

Fig. 6. *Explorer XI and Attached Fourth-Stage Rocket Casing. End-over-end tumbling motion is designed for maximum coverage by gamma-ray telescope. Disk leaving top of payload is micrometeorite shield to protect telescope; shield can be removed by ground command near end of experiment lifetime (about one year) to provide data for distinguishing between gamma radiation produced when cosmic rays strike the shield and that actually coming from space. The two beams projecting from end of satellite (foreground) show "lines of sight" of sun and earth sensors. NASA photograph.*

trons generally cause local concentrations of energy in the layer in which the interaction occurs.

Two optical-aspect sensors aimed forward along the telescope axis produce characteristic signals when they scan across the earth's horizon or twilight zone, or close to the sun. Knowledge of the satellite's aspect at all times, coupled with the directional character of the telescope, permits the direction of arrival of the incoming gamma rays to be determined.

Preliminary Results: Preliminary analyses of real-time data telemetered by Explorer XI during its first few weeks in orbit indicate that radiation background intensity approximately followed prior estimates by the experimenters. Gamma-ray counting rates were also generally as expected. Several months of data acquisition are needed, however, before firmly based conclusions on gamma-ray distributions in space can be reached.

Initial data on satellite temperatures showed a range of about 30° C to 50° C (about 85°-120° F) for the battery pack, temperatures usually very close to 30° C for the experimental package, and about 4°-23° C (39°-73° F) for the solar cells.

Radio and Telemetry Equipment

The satellite is powered by a system employing solar cells to charge nickel-cadmium batteries, and carries two phase-modulated transmitters. Frequency-modulated outputs from the various sub-systems are combined in two mixing amplifiers. The output of one of these amplifiers goes to a low-power, phase-modulated transmitter operating continuously on a frequency of 108.06 megacycles, with a power output of 20 milliwatts, and radiated by a split dipole antenna made up of the two halves of the satellite structure (payload and fourth-stage rocket).

The output of the second mixing amplifier feeds a tape recorder, which in turn feeds a higher-power (125 milliwatt), phase-modulated transmitter. This transmitter is connected to a loop antenna whose plane is perpendicular to the longitudinal axis of the satellite structure. The recorder records continuously for 100 minutes and plays back the stored data in two minutes.

In the first few weeks after the date of launch, real-time data was telemetered satisfactorily, resulting in acquisition of about 50% of the total usable data obtained by the satellite. The satellite tape recorder, however, has not functioned properly.

Tracking and Data Acquisition

The NASA Minitrack system is being utilized for tracking and data reception. Approximately ten stations track the Explorer XI satellite and receive data transmitted over the low-power transmitter. Four of these stations were also to receive and record tape-recorded data from the satellite's high-powered transmitter. However, because of the malfunction of the tape-recorder, it has been necessary to expand acquisition of real-time data by addition of telemetry acquisition stations, in Hawaii, in California, and possibly in India. Analysis and interpretation of the data received from the satellite is being carried out at the Massachusetts Institute of Technology.

SPACEWARN

Communications Network for World-Wide Rapid Dissemination of Satellite Information

The following report is based on material prepared by A. H. Shapley, Vice-Chairman of the US National Committee for the IGY and Spokesman for ICSU International World Days Service.

Mindful of the need for the rapid dissemination of information on IGY satellite launchings and orbits, the CSAGI Rocket and Satellite Conference, held in Washington, D. C., October 1957, and the Fifth Meeting of CSAGI, held in Moscow in August 1958, recommended that the IGY World Days communication network (see *Bulletin Nos. 5, 23,* and *47*) be made available for this purpose. Accordingly, during IGY and IGC-59, this communication channel was used for satellite launching announcements, orbital predictions, and approximate tracking observations, as well as for its original purpose of alerting geophysicists throughout the world of impending solar-terrestrial events, or of their onset.

At the third meeting of the Committee on Space Research (COSPAR—established by the International Council of Scientific Unions in 1958), held in Nice, France, January 1960, it was concluded that an international channel for rapid communication of prediction information needed for tracking and conducting other satellite observations should continue to be available. COSPAR accordingly recommended that the IGY World Warning Network continue to be used for this purpose, under the name of SPACEWARN.

The main types of messages transmitted by SPACEWARN are launching announcements, orbital predictions, and approximate tracking observations. The messages go from one continent to another by telegram, and further distribution to national centers and individual laboratories is accomplished by the most effective rapid means available.

SPACEWARN Network

The SPACEWARN network for rapid communication of satellite information consists of four Satellite Regional Warning Centers (SRWC), located as follows (telegraphic addresses are given in parentheses):

Western Pacific

Radio Research Laboratories
Kokubunji, Tokyo, Japan
(AGI KOKUBUNJI)

Western Europe

Fernmeldetechnisches Zentralamt
Rheinstrasse 110
Darmstadt, German Federal Republic
(IONOSPHARE DARMSTADT)

and Radio Research Station
Ditton Park
Sloughs (Bucks.), England
(RADSEARCH SLOUGH)

Eurasia

Astronomicheskiy Sovet
Akademii Nauk
Bol'shaya Gruzinskaya
dom 10, Moscow, USSR
(COSMOS MOSCOW)

Western Hemisphere

North Atlantic Radio Warning Service
Box 178
Fort Belvoir, Virginia, USA
(AGIWARN WASHINGTON)

Associate centers, which handle some satellite message traffic, are located in the Netherlands and at Sydney and Salisbury, Australia.

In general, satellite information is delivered to the network at AGIWARN or COSMOS. A message is then sent by telegram to each of the other three SRWC's for distribution to stations within the SRWC regions according to the regional plans. In the Western Hemisphere, for example, announcement of the successful launching of a United States scientific satellite is telegraphed to AGIWARN by the Space Science Board of the US National Academy of Sciences. The message is then transmitted by AGIWARN over the SPACEWARN network, usually within one hour of receipt, directly to the other SRWC's, to the associate centers in the Netherlands and Australia, and to Western Hemisphere and US addresses that have standing requests for such information.

Launching Messages

The SRWC for the Western Hemisphere (AGIWARN) has received from United States launching authorities, and distributed internationally, 19 launch messages, for the following US scientific satellites and space probes: Explorer I, III, IV, VI, VII, VIII, IX, X, XI, and XII; Vanguard I, II, and III; Pioneer IV and V; Tiros I, II, and III; and Echo I. The message is identified by the code word LUNAVER, followed by digits indicating the date and time of the message. The body of the message is simply worded, providing, as appropriate, the following information: scientific and popular names of satellite or probe; launch and injection dates and times; coordinates of injection point; launch site; preliminary orbital elements; shape, size, and weight of payload; summary description of scientific instruments; radio frequencies and power for tracking and telemetry; and related information. The signature is AGIWARN.

On three occasions (for Sputnik III and Lunik II and III), announcements of USSR launchings were distributed over the World Days network. In August 1961, a launching message from the USSR, concerning the Vostok II manned spacecraft, was received by the IWDS Spokesman and introduced into the SPACEWARN network.

Orbital Predictions

Predictions of the future paths of satellites are expressed as (i) "station predictions," applicable to a specified tracking station and a specified passage of the satellite; (ii) "sub-satellite points," giving the coordinates and time of passage over one or more points of a terrestrial grid (for example, longitude and time of passage over the equator); or (iii) orbital elements, or the so-called "modified orbital elements," from which the time and aspect for any tracking location can be computed for any passage. It is to be noted that (ii) and (iii) are of widespread or universal applicability, while (i) is of use only to the particular tracking station concerned.

AGIWARN receives from US computing centers the current modified orbital elements for most satellites and distributes them internationally over the SPACEWARN network in an abbreviated coded message form. These AGIWARN messages are identified by the code word LUNACEN, followed by a date-time group. The body of the message, introduced by the code word SATOR (see below) and specifying the satellite and epoch, is in the SATOR code. In 1960, AGIWARN distributed 248 SATOR messages concerning 17 satellite objects. Such messages have not yet been introduced into the SPACEWARN network from COSMOS.

Equatorial-crossing predictions are provided to AGIWARN for certain satellites and are distributed by mail. Station predictions, in accordance with conclusions reached at the Nice meeting of COSPAR, should in general go directly from computing centers to the respective stations, utilizing the SPACEWARN network only under special arrangements. During 1960, no station-prediction messages flowed through SPACEWARN; the last one was sent in March 1959 from COSMOS to a station in Ecuador.

Tracking Observations

The SPACEWARN network has provided a channel for the prompt reporting of tracking observations to computing centers for the purpose of improving future predictions. Tracking data are not interchanged among all SRWC's; in general, they are sent by the tracking station headquarters to the nearest SRWC, which then forwards them to the SRWC in the region of the computing center of the launching agency. In this case, the SPACEWARN network serves as an international channel for communication from a particular tracking station to a particular computing center, although in principle the data are available to any interested group.

Tracking reports for United States satellites are received quite regularly by AGIWARN through SPACEWARN channels from COSMOS, IONOSPHARE DARMSTADT, and NERA for tracking stations in their regions. In 1960, AGIWARN received 87 such messages concerning 18 US satellites. Tracking reports of USSR satellites were forwarded from AGIWARN to COSMOS. It is not known to what extent reports are forwarded through SPACEWARN channels from other SRWC's, although a number of stations apparently send data through the Darmstadt SRWC.

Message Code Words

The code words now in common use are the following:

SATOR:	Current (modified) orbital elements
SATOF:	Optical tracking observations
SATUG:	Optical tracking observations
COSMOS:	Optical tracking observations

The definitive description and key to SATOR are given in *IGY Satellite Report Series Number 7*, available from IGY World Data Center A, US National Academy of Sciences, 2101 Constitution Avenue, N.W., Washington 25, D. C. A version that appears in the "IGY Instruction Manual for World Days and Communications," *IGY Annals*, Vol. VII, Part I, Pergamon Press, 1959, is also usable, and contains descriptions and keys to the other codes as well.

Distribution of Messages

Each of the Satellite Regional Warning Centers is responsible for arranging to forward messages to interested national centers or individual laboratories within its region. Details of such arrangements vary widely, according to practical possibilities, and no attempt is made to arrange a uniform pattern. A complete census of the use of SPACEWARN channels within regions is not available at present, although it appears likely that more than 100 institutions and stations are served. Institutions desiring satellite prediction information should get in touch with the appropriate Satellite Regional Warning Center (above).

1961 COSPAR Modifications of SPACEWARN Plan

In accordance with recommendations adopted by COSPAR in April 1961 at its meeting in Florence, Italy, a number of improvements are being made in the SPACEWARN plan. Among them are the following: All messages are to be identified as SPACEWARN messages, and revised codes for the various types of SPACEWARN messages are to be issued by autumn of 1961. Abbreviated launching announcements and current orbital predictions in the SATOR code are being added to daily broadcasts of solar and geophysical data by the URSIgramme centers at Bagneux (Paris) and Kokubunji (Tokyo). COSPAR also suggested that similar broadcasts in other regions might help to improve the effectiveness of regional distribution of SPACEWARN data.

Each national member of COSPAR is to designate an individual to be the national contact for SPACEWARN to help identify the stations requiring SPACEWARN messages and to recommend changes or improvements necessary to assure effective communication in their areas.

Man's Role in Space

With the recent announcement by President Kennedy that manned landing on the Moon constituted a national objective of the space program during the present decade, public discussion has been concerned with the values of such an effort. For three years the Space Science Board of the National Academy of Sciences has been studying scientific aspects of space, including the role of man. On this topic the Board adopted a formal position at its February 10-11, 1961 meeting, which it submitted to the Government on March 31, 1961.

The Space Science Board has recommended that *scientific exploration of the Moon and planets should be clearly stated as the ultimate objective of the U. S. space program for the foreseeable future.* This objective should be promptly adopted as the official goal of the United States space program and clearly announced, discussed and supported. In addition, it should be stressed that the United States will continue to press toward a thorough scientific understanding of *space,* of solving problems of manned space exploration, and of development of applications of space science for man's welfare.

The Board concluded that it is not now possible to decide whether man will be able to accompany *early* expeditions to the Moon and planets: many intermediate problems remain to be solved. However, the Board strongly emphasized that planning for scientific exploration of the Moon and planets must at once be developed on the premise that man will be included. Failure to adopt and develop our national program upon this premise will inevitably prevent man's inclusion, and every effort should be made to establish the feasibility of manned space flight at the earliest opportunity.

From a scientific standpoint, there seems little room for dissent that man's participation in the exploration of the Moon and planets will be essential, if and when it becomes technologically feasible to include him. Man can contribute critical elements of scientific judgment and discrimination in conducting the scientific exploration of these bodies which can never be fully supplied by his instruments, however complex and sophisticated they may become. Thus, carefully planned and executed manned scientific expeditions will inevitably be the more fruitful. Moreover, the very technical problems of control at very great distances, involving substantial time delays in command signal reception, may make perfection of planetary experiments impossible without manned controls on the vehicles.

There is also another aspect of planning this country's program for scientific exploration of the Moon and planets which is not widely appreciated. In the Board's view, the scale of effort and the spacecraft size and complexity required for manned scientific exploration of these bodies is unlikely to be greatly different from that required to carry out the program by instruments alone. In broad terms, the primary scientific goals of this program are immense: a better understanding of the origins of the solar system and the universe, the investigation of the existence of life on other planets and, potentially, an understanding of the origin of life itself. In terms of conducting this program a great variety of very intricate instruments (including large amounts of auxiliary equipment, such as high-powered transmitters, long-lived power supplies, electronics for remote control of instruments and, at least, partial data processing) will be required. It seems obvious that the ultimate investigations will involve spacecraft whether manned or unmanned, ranging to the order of hundreds of tons so that the scale of the vehicle program in either case will differ little in its magnitude.

Important supporting considerations are essential to realization of these concepts:

(a) Development of new generations of space vehicles, uniquely designed for use in space research and not adaptations of military rockets, must proceed with sufficient priority to ensure that reliable vehicles of adequate thrust are available for lunar and planetary research. This program should also include development of nuclear stages as rapidly as possible.

(b) Broad programs designed to determine man's physiological and psychological ability to adapt to space flight must likewise be pushed as rapidly as possible. However, planning for "manned" scientific exploration of the Moon and the planets should be consummated only as fast as possible consistent with the development of all relevant information. The program should not be undertaken on a crash basis which fails to give reasonable attention to assurance of success or tries to by-pass the orderly study of all relevant problems.

(c) Consideration should be given soon to the training of scientific specialists for spacecraft flights so that they can conduct or accompany manned expeditions to the Moon and planets.

The Board strongly urges official adoption and public announcement of the foregoing policy and concepts by the U. S. Government. Furthermore, while the Board has here stressed the importance of this policy as a *scientific* goal, it is not unaware of the great importance of other factors associated with a United States man in space program. One of these factors is, of course, the sense of national leadership emergent from bold and imaginative U. S. space activity. Second, the members of the Board as individuals regard man's exploration of the Moon and planets as potentially the greatest inspirational venture of this century and one in which the entire world can share; inherent here are great and fundamental philosophical and spiritual values which find a response in man's questing spirit and his intellectual self-realization. Elaboration of these factors is not the purpose of this document. Nevertheless, the members of the Board fully recognize their parallel importance with the scientific goals and believe that they should not be neglected in seeking public appreciation and acceptance of the program.

The membership of the Space Science Board and its committees, which includes leading scientists in various fields from all parts of the country, includes:

The Board: L. V. Berkner (Chairman), Harrison S. Brown, Leo Goldberg, H. Keffer Hartline, Donald F. Hornig, William W. Kellogg, Christian J. Lambertsen, Joshua Lederberg, Colin S. Pittendrigh, Richard W. Porter, Bruno B. Rossi, Alan H. Shapley, John A. Simpson, Harold C. Urey, James A. Van Allen, O. G. Villard, Jr., Harry Wexler, George P. Woollard, Hugh Odishaw (Executive Director), and R. C. Peavy (Secretary).

Committee on the Chemistry of Space and Exploration of Moon and Planets: Harold C. Urey (Chairman), Harrison S. Brown (Vice Chairman), Harry H. Hess, A. R. Hibbs, Mark Inghram, Zdenek Kopal, Gordon J. F. MacDonald, Frank Press, William M. Sinton, G. de Vaucouleurs, Fred L. Whipple, G. A. Derbyshire (Secretary).

Committee on Optical and Radio Astronomy: Leo Goldberg (Chairman), Lawrence H. Aller, Horace W. Babcock, Gerald M. Clemence, A. D. Code, John W. Evans, Jr., John Findlay, Herbert Friedman, Roger Gallet, G. H. Herbig, Frederick T. Haddock, Jr., Walter Orr Roberts, Lyman Spitzer, Jr., Martin Schwarzschild, Edward R. Dyer (Secretary).

Committee on International Relations: Richard W. Porter (Chairman), Herbert Friedman, Leo Goldberg, Hugh Odishaw, Homer E. Newell, Jr., Howard P. Robertson, Alan H. Shapley, Harry Wexler, Joel Orlen (Secretary).

Committee on Space Projects: Bruno B. Rossi (Chairman), Thomas Gold, Salvador E. Luria, Philip Morrison, J. P. T. Pearman (Secretary).

Committee on The Atmospheres of the Earth and Planets: Alan H. Shapley (Chairman), Henry G. Booker, Joseph W. Chamberlain, Robert Jastrow, C. Gordon Little, Laurence A. Manning, Arthur H. Waynick, R. C. Peavey (Secretary).

Committee on Physics of Fields and Particles in Space: John A. Simpson (Chairman), James A. Van Allen (Vice Chairman), Joseph Chamberlain, William Kraushaar, Eugene N. Parker, E. H.

Vestine, John Winckler, J. P. T. Pearman (Secretary).

Committee on Meteorological Aspects of Satellites: Harry Wexler (Chairman), Charles C. Bates, George Benton, Sigmund Fritz, William W. Kellogg, Norman Phillips, Ernst Stuhlinger, Verner E. Suomi, William K. Widger, Jr., Edward R. Dyer (Secretary).

Committee on Geodesy: G. P. Woollard (Chairman), R. K. C. Johns, D. A. Lautman, William Markowitz, W. J. O'Sullivan, Donald A. Rice, Hellmut Schmid, Charles A. Whitten, Edward R. Dyer (Secretary).

Committee on Upper Atmosphere Rocket Research: W. W. Kellogg (Chairman), H. J. aufm Kampe, Warren W. Berning, W. W. Elam, Robert D. Fletcher, Herbert Friedman, Stanley M. Greenfield, John E. Masterson, Willis Webb, Harry Wexler, G. A. Derbyshire (Secretary).

Committee on Exobiology: Joshua Lederberg (Chairman), Paul Berg, Melvin Calvin, Richard Davies, Norman Horowitz, A. G. Marr, Daniel Mazia, Aaron Novick, Carl Sagan, C. B. van Niel, Harold Weaver, G. A. Derbyshire (Secretary).

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IGY BULLETIN

A monthly survey of plans, activities and findings in geophysics—with emphasis on United States contributions to the International Geophysical Year, International Geophysical Cooperation–1959, and similar international endeavors including the World Magnetic Survey, the Year of the Quiet Sun, the Indian Ocean Expedition, the Antarctic research program, and space exploration and research. Preparation and publication of the Bulletin *is supported by the National Science Foundation.*

Survey of the Earth's Magnetic Field

The World Magnetic Survey

The IGY program in geomagnetism included a proposal for a world-wide survey of the earth's magnetic field. Inasmuch as the IGY itself was timed to coincide with the period of maximum solar activity, when magnetic storms and other disturbances of the geomagnetic field are at their peak, major phases of the magnetic survey were deferred until a time of solar quiet so that the field could be surveyed with a minimum of interference from solar-induced disturbances. Present planning calls for the World Magnetic Survey (WMS), which uses data gathered since 1955, to heighten its efforts during the International Year of the Quiet Sun (IQSY), April 1964–December 1965, when, it is predicted, the minimum of solar activity will occur; survey activity now underway will also contribute to the WMS.

The Geomagnetic Field

At the earth's surface and in its atmosphere the geomagnetic field closely resembles that of a short bar magnet imagined to be located at the earth's center with its north-seeking pole directed towards Antarctica, or of a uniformly magnetized sphere (see Fig. 1) the axis of which is inclined about 11.5° to the earth's axis of rotation. The points where the axis of the sphere intersect the earth's surface are the geomagnetic poles; the geomagnetic pole in the Northern Hemisphere is located near Thule, Greenland.

The unit of magnetic field intensity commonly used is the *oersted,* which is defined in terms of the unit magnetic pole. In the centimeter-gram-second system of units, two unit magnetic poles exert a force of one dyne (one gram-centimeter per second per second) on each other when at a separation of one centimeter. A field of one oersted

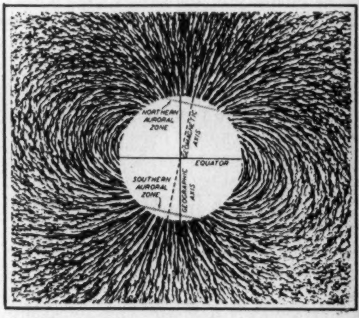


Fig. 1. *Schematic Representation of the Earth's Magnetic Field. Field resembles that of a short bar magnet near Earth's center, with north-seeking pole directed towards Antarctica and with axis of corresponding uniformly magnetized sphere inclined about 11.5° to Earth's rotation axis.*

exerts a force of one dyne on a unit magnetic pole. The magnetic field intensity is sometimes given in *gauss;* the gauss was formerly the unit of intensity but was redefined in 1932 as the unit of magnetic induction such that an induction field of one gauss produces an electromotive force of one abvolt, or 10^{-8} volts, in a straight wire one centimeter in length that moves perpendicularly through the induction field at a velocity of one centimeter per second. The gauss and oersted are essentially equivalent measures of field intensity, differing only in their application to magnetic fields arising from different causes.

The field intensity between the pole pieces of a small toy horseshoe magnet may be hundreds of oersteds; the fields of industrial magnets or the magnets used in magnetrons may be some thousands of oersteds; the fields of magnets in cyclotrons and other large high-energy accelerators may be approximately ten thousand oersteds; the field in the gap of a large low-frequency high-fidelity loudspeaker may approach twenty-thousand oersteds; and super-high magnetic fields of nearly a million oersteds have been produced in laboratory experiments.

The intensity of the earth's field is approximately one-half oersted, by most standards of common experience a weak field. Yet, the geomagnetic field occupies a very large volume and, since the energy of a magnetic field is proportional to the volume, the field is a most important factor in the terrestrial environment, screening the earth's equatorial regions from cosmic rays with energies of a few tens of billions of electron volts and trapping charged particles in the Van Allen Radiation Belts.

The magnetic energy in a shell one kilometer thick around the earth near its surface is approximately 5×10^{21} ergs (or about 10^{8} kilowatt-hours); since the geomagnetic field is still distinguishable from the background field of interplanetary space at distances of 10–13 earth radii, the total energy of the geomagnetic field is clearly quite high. On an even larger scale, it is estimated that the magnetic fields of the galaxies, with strengths of the order of 10^{-5} to 10^{-6} oersted, contain energies 100 to 1000 times the total energy emitted by stars. Small changes in the earth's field are usually measured in units (called *gammas*) of 10^{-5} oersted.

The actual geomagnetic field is somewhat irregular as a result of inhomogeneities in the earth's crust and, possibly, in the upper mantle as well. These inhomogeneities may be, for example, concentrations of rock rich in iron. Most rocks, however, are magnetic to some degree, and large-scale features of the earth's crust commonly have magnetic anomalies, or departures from uniformity in the field associated with them.

In addition, the seat of the magnetic field in the interior of the earth appears to be non-uniform and changing slowly with time. Whatever the origin of the field is—and there is only imperfect theory today concerning this problem—it seems necessary to conclude that there is a relation between the causal mechanism and the earth's axis of rotation. This coupling, however, permits the magnetic axis to be tilted with respect to the rotational axis, as noted earlier, and to be displaced. The displacement was deduced from harmonic analysis and later confirmed by careful longitude and latitude surveys of cosmic-ray intensity in the equatorial region; it is estimated that the magnetic axis is displaced at the earth's center by some 200 km (125 mi) in the direction away from the South Atlantic Ocean. The direction of the displacement was one of the factors in selecting the South Atlantic as the site for the Argus experiment (see *Bulletin No. 27*).

From observations beginning during the nineteenth century (after K. F. Gauss had invented the first practical magnetometer and organized a cooperative network of magnetic observatories) it has been learned that the strength of the geomagnetic field has been decreasing—about 6% in the past 100 years. It has also been learned that the patterns of change in the earth's field

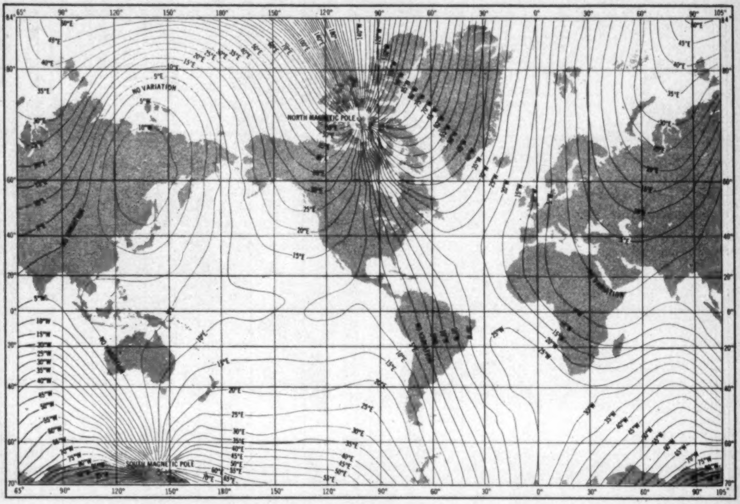


Fig. 2. *World Map of Magnetic Declination, D, 1955. Lines connect points of equal variation of compass needle from geographic north. Courtesy of* Encyclopaedia Britannica. (*Map based on US Navy Hydrographic Office chart.*)

themselves change, moving westward at about 10′ of longitude per year. The main features of the field, and particularly its changes, provide students of the earth with clues to mechanisms in the earth's interior that are thought to give rise to the magnetic field. At the least, it is clear that any theory of the origin of the field must account for its tilt, displacement, and changes as measured at the surface.

Components of the Field: Since the magnetic field has both magnitude and direction at any point, it is a vector quantity, $\bar{F}$, which may be described by components resolved along any convenient reference frame. For mapping purposes, the geomagnetic field is commonly described in terms of:

F—the strength of the field, or the absolute magnitude of the total-field vector, $\bar{F}$

H—the horizontal intensity, or the magnitude, at any point, of the vector $\bar{H}$ (the component of $\bar{F}$ projected on a plane tangent to the earth's surface at that point)

Z—the vertical intensity, or the magnitude, at any point, of the vector $\bar{Z}$ (the component of $\bar{F}$ projected on the vertical at that point)

D—the declination, or the angle that $\bar{H}$ makes with the meridian of longitude through any point (sometimes also termed the variation of the compass)

I—the inclination, or the angle that $\bar{F}$ makes with the vertical at any point.

For the actual geomagnetic field, the magnetic poles are defined as those places where the inclination is 90°. The magnetic equator, conversely, is defined as the locus of points where the inclination is zero. Magnetic anomalies may be large enough at some locations to mask the character of the general geomagnetic field, and for mapping the field on a large scale, for example the entire

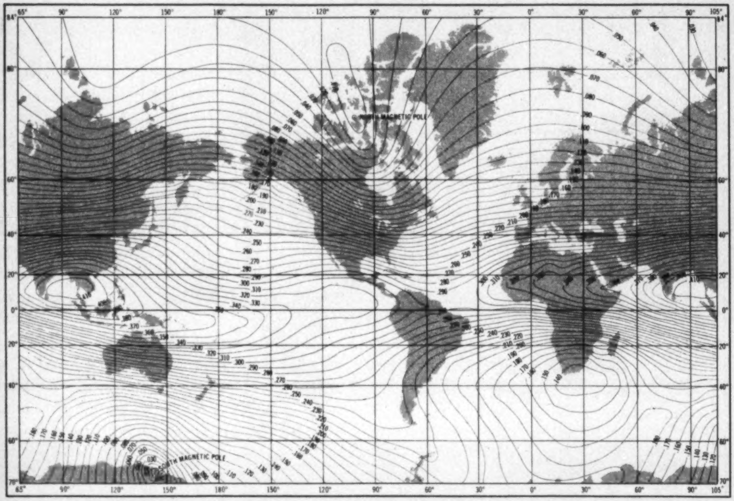


Fig. 3. *World Map of Horizontal Intensity, H, of Geomagnetic Field, 1955. Lines connect points of equal value (expressed in oersted) of H. Courtesy of* Encyclopaedia Britannica. (*Map based on US Navy Hydrographic Office chart.*)

earth, the local anomalies and small-scale distortions are averaged out.

Types of Geomagnetic-Field Maps: Figures 2, 3, and 4 show the 1955 maps of D, H, and Z, compiled by the US Coast and Geodetic Survey with the cooperation of the US Navy Hydrographic Office, the United States institutions responsible for preparing such information for national use. (Agencies in other countries also prepare maps of the geomagnetic field on a regional or a global basis for their own needs.) Maps of declination, D, of the field are usually prepared every five years in the US, and maps of H, Z, F, and I are recompiled every 10 years.

Between the years when new maps are issued, the work of measuring absolute values of the field elements continues at the network of permanent observatories throughout the world. In addition, temporary locations are occupied with portable equipment so as to provide more complete coverage.

The observatory network also provides a means for keeping track of the slow changes in the field, or the secular variation. It is necessary to know how the field is changing in order to correct all readings to the epoch of the next chart. Thus, after the 1955 charts (Figs. 2, 3, and 4) were completed, measurements in the period 1955–1960 were corrected to show the value of the various field elements as of 1960, the epoch of the next chart. Similarly, although special emphasis will be placed on the World Magnetic Survey during the period 1964–1965, measurements made for a decade or more prior to 1965 will be used to compile the WMS charts, with appropriate corrections for the secular change. Figure 5 shows the annual change in Z; similar world maps are prepared to show the secular variation in D and the other field elements.

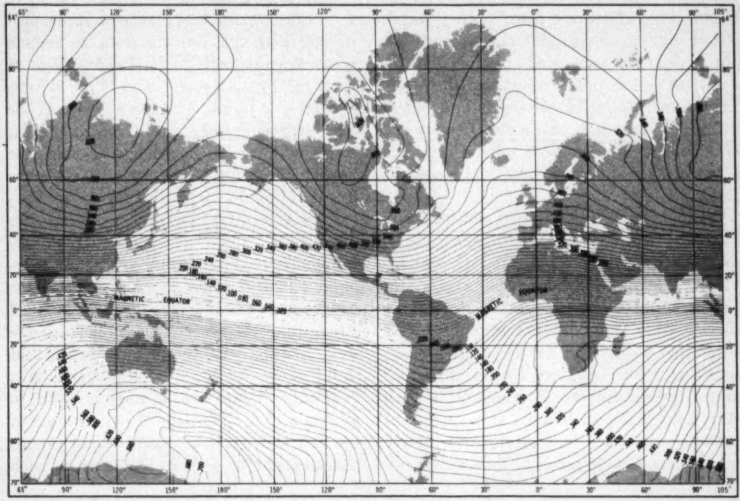


Fig. 4. *World Map of Vertical Intensity, Z, of Geomagnetic Field, 1955. Lines connect points of equal value (expressed in oersted) of Z. Courtesy of* Encyclopaedia Britannica. (*Map based on US Navy Hydrographic Office chart.*)

Methods of Mapping the Geomagnetic Field

Measurements on Land: As mentioned above, the network of permanent observatories provides a base for survey of the geomagnetic field over land areas, and temporary locations help fill in the coverage. Series of measurements are made over a period of at least several days in order to eliminate the diurnal variation, which arises from daily exposure of the upper atmosphere to heating and ionization by solar radiation and from wind systems generated under the influence of the solar tidal force.

For land stations, the terrestrial coordinate reference frame—north-south, east-west, vertical—can be determined with high accuracy through astronomical methods. The values of the field strength can be determined to a precision of one gamma and the declination and inclination to 0.2 minutes of arc.

Measurements at Sea: Since the surface of the planet is approximately three-fourths water, the magnetic field must be measured at sea as well as on land in order to provide sufficient coverage for accurate mapping. To help fill this gap, specially designed magnetometers were used aboard the non-magnetic ship *Carnegie,* operated by the Carnegie Institution of Washington, in the period 1909 to 1929, until, in 1929, the wooden vessel was destroyed by fire. Since then, a few other cruises by non-magnetic ships have been made, but not until recently has another such vessel been generally available for magnetic observations at sea. This vessel is the USSR non-magnetic ship *Zarya,* which was fitted out during the IGY and has been in steady use since then compiling new magnetic information in oceanic areas.

Non-magnetic ships are constructed of materials such as wood, brass, and bronze that will not distort measurements of the earth's field. They are often sailing vessels fitted with small auxiliary engines and with the magnetic measuring instruments located as far as practicable from the ship's machinery. Electrical wiring is laid out to minimize external magnetic fields, and small magnets are placed around the ship, if needed, to offset any residual magnetic fields.

The magnetometers aboard non-magnetic ships are regularly checked against standard instruments at land stations, particularly at island locations. The *Zarya*, for example, put in at San Juan, Puerto Rico, in December 1958, and its instruments were compared with those at the magnetic observatory operated there by the US Coast and Geodetic Survey. A magnetic survey ship must make such stops at a variety of latitudes in order to calibrate its instruments over a wide range of field values.

Ship measurements can obtain values of the field elements to a precision of one part in 300 and can provide data in remote oceanic areas. The main disadvantage of such surveys, however, is that much time is needed to produce a magnetic grid of the vast oceanic regions. Moreover, at present there is only one non-magnetic ship, the *Zarya*, instrumented for vector measurements of the magnetic field. Many oceanographic research ships use a magnetometer mounted in a "fish," which is towed by cable far enough behind the ship so that the magnetic field of the ship does not influence the instruments. However, only the total-field strength, F, is generally obtained in this way. Vector magnetometers exist that could, theoretically, also be mounted in a fish, but it would not be possible either to maintain or to determine the orientation of the fish with sufficient accuracy to permit measurement of H and D. Even so, such

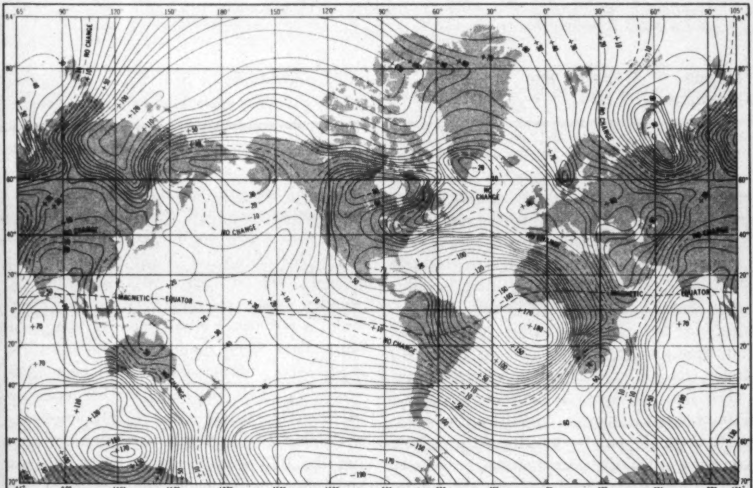


Fig. 5. *World Map of Secular Variation in Vertical Intensity, 1889–1955. Lines connect points of equal annual change, expressed in gammas (oersted value times 10^{-5}). Courtesy of* Encyclopaedia Britannica. (*Map based on US Navy Hydrographic Office chart.*)

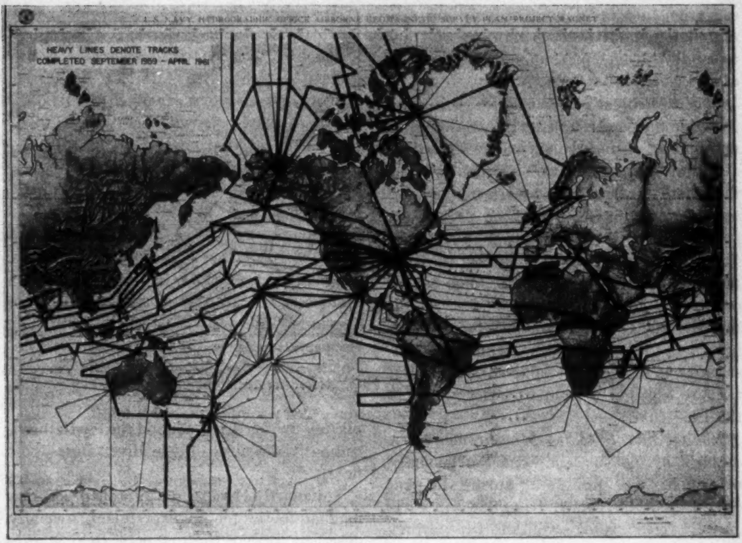

U.S. NAVY HYDROGRAPHIC OFFICE AIRBORNE GEOMAGNETIC SURVEY PLAN PROJECT MAGNET
HEAVY LINES DENOTE TRACKS
COMPLETED SEPTEMBER 1959 – APRIL 1961

Fig. 6. *Flight Lines of Project Magnet of US Navy Hydrographic Office. USNHO chart.*

measurements of F alone can be used to help fill in gaps in magnetic coverage.

Airborne Measurements: It is now possible to survey the geomagnetic field with aircraft, using recently developed total-field magnetometers such as the flux-gate or proton-precession instruments. Measurements obtained by airborne techniques have proved most useful in geophysical exploration for mineral deposits and in studies of the structure of the earth's crust. The detail obtained, however, is too fine for mapping purposes as the flights are made at low altitudes and attention is concentrated on local anomalies. It has also proved possible to install vector magnetometers in aircraft for determinations of F, D, and I.

Canadian scientists have surveyed much of Canada from the air and have made some crossings of the Atlantic and Pacific Oceans. A major program of airborne survey—Project Magnet—in which two aircraft (a DC-4 and a Super-Constellation) have been fitted with extensive navigation equipment and vector magnetomers, is now being carried out by the US Navy Hydrographic Office. In this program, the true heading and magnetic heading are determined, permitting calculation of D, and I and F are also measured; thus, a complete description of the field is obtained. Figure 6 shows Project Magnet flight lines, both planned and already flown. A more-or-less regular grid pattern with 300-km (200-mi) spacing will be obtained over the ocean areas. Instruments are checked wherever possible against standard instruments at land observatories. It is calculated that under good conditions the total intensity is measured with a precision of ± 15 gammas and angular directions are obtained to within ± 0.1° of arc. Flights are made at altitudes ranging from about 1500 to 6000 meters, with most at about 3000 m; and observations are taken continuously but tabulated for about every 5 minutes of track to achieve a spacing along the flight path of 25 km.

Several Project Magnet flights were completed in the Antarctic (see Fig. 7) before an accident destroyed the Super-Constellation; a similar aircraft is now being modified and fitted out to carry on the work of the project. Meanwhile, the DC-4 has proved capable of providing long-range flights, six flights around the world having already been made with this aircraft. Some earlier data from Project Magnet were available for the 1960 D chart and data being taken now and for the next few years will constitute one of the most important contributions to the World Magnetic Survey and to the 1965 charts.

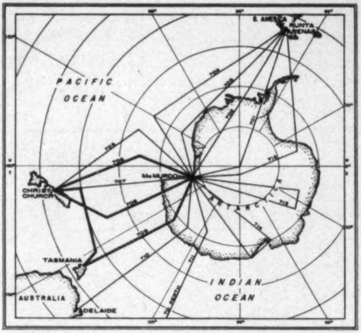


Fig. 7. *Project Magnet Flight Lines in the Antarctic. Heavy lines are flights completed as of October 1960.*

Rocket and Satellite Measurements: A number of measurements of the geomagnetic field have been made during the past few years by instrumentation flown in various US rockets and satellites. Proton-precession magnetometers have been carried aboard rockets to explore atmospheric electric currents arising from some solar disturbances and to study the diurnal solar-ionization and tidal forces near the equator.

A magnetometer carried by space probe Pioneer I explored the geomagnetic field to distances of about 115,000 km (70,000 mi). Results indicated that the field intensity decreased with distance from the earth according to an inverse-cube relationship between 3.7 and about 7 earth radii from the center of the earth, with large-scale fluctuations beyond. (The average radius of the earth is about 6370 km, or 3960 mi.) The data also indicated a transition between the geomagnetic and the interplanetary field at about 13.6 earth radii. From data of Explorer VI, which also carried a magnetometer, it was found that the field decreased as expected to about 5 earth radii, with regular large-scale deviations beyond, at least to 8 earth radii. It was deduced that the cause of the deviations is a ring current arising from trapped low-energy plasma, which drifts around the earth longitudinally because of the diverging dipole field.

Vanguard III carried a proton-precession magnetometer for an experiment specially designed to map the magnetic field at satellite altitudes (see *Bulletin No. 28*). Proton-precession magnetometers were also installed at telemetry stations for simultaneous ground-control observations during satellite passes. NASA scientists who analyzed the Vanguard III data have concluded that a simply instrumented satellite can give valuable information on the distant field and permit considerable refinement of the mathematical representations of the real geomagnetic field. (Details of Vanguard III results can be found in *Bulletin No. 46*). It is apparent from Figure 8, which shows some of the coverage obtained thus far by rocket and satellite magnetic observations, that there are still great gaps for which data are lacking; it is hoped that these gaps will be reduced by future satellite experiments.

General Plans for the WMS

International: Prior to the IGY the International Association of Geomagnetism and Aeronomy (IAGA) of the International

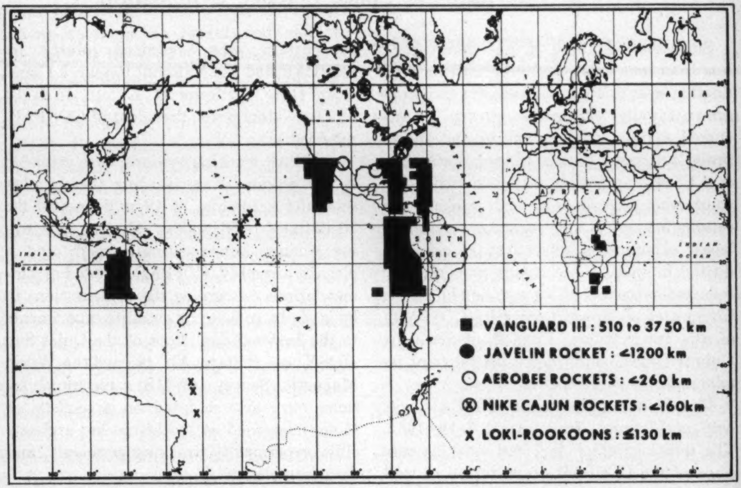
Union of Geodesy and Geophysics (IUGG) appointed a Special Committee on the World Magnetic Survey and Magnetic Charts, with E. H. Vestine as Chairman, to study the technical requirements for the World Magnetic Survey. Meetings were held during the XIth and XIIth IUGG General Assemblies at Toronto (1957) and at Helsinki (1960). The Committee has circulated recommendations regarding precision and spacing of measurements as well as possible satellite observations.

The International Geophysics Committee (CIG) of the International Council of Scientific Unions (ICSU, parent organization for international scientific unions) was assigned responsibility for international coordination of the WMS. The CIG requested ICSU's Committee on Space Research (COSPAR) to study possible contributions to the WMS by rocket and satellite observations. At the last meeting of COSPAR in Florence, Italy, April 1961, it was suggested that two satellites equipped with magnetometers be launched into polar orbits—one at a height of several hundred kilometers and the other at a distance of about 10 earth radii.

The international recommendations stemming from these meetings are now being considered by many countries as they plan their contributions to the WMS. A manual on observations and data analysis is also being prepared by the IAGA Committee for the use of scientists interested in participating in WMS.

United States: A Panel on the WMS, chaired by E. H. Vestine, was organized by the Geophysics Research Board of the National Academy of Sciences (discussed in *Bulletin No. 48*). Subsequent to the first meeting of the Panel, A. J. Zmuda, Applied Physics Laboratory of the Johns Hopkins University and J. F. McClay, Air Force Cambridge Research Laboratories, have joined the membership.

At its initial meeting, the Panel discussed the international recommendations and reviewed the expected United States contributions. Project Magnet, described above,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ATLANTIC OCEAN
EUROPE
ASIA
AFRICA
SOUTH AMERICA
INDIAN OCEAN
AUSTRALIA
INDIAN OCEAN
■ VANGUARD III : 510 to 3750 km
● JAVELIN ROCKET : <1200 km
○ AEROBEE ROCKETS : <260 km
⊗ NIKE CAJUN ROCKETS : <160km
X LOKI-ROOKOONS : ≤130 km

Fig. 8. *Areas of Magnetic Observations by Rockets and Satellites through 1960.*

will constitute one of the major US observational programs. In addition, the US Coast and Geodetic Survey plans to make observations at a network of field locations as well as to continue its normal observation program at the permanent observatories. Absolute measurements are also being made by Coast and Geodetic Survey personnel in Antarctica, both at the permanent stations and, with portable equipment, on over-snow traverses that are part of the glaciological research program.

The Panel has discussed the important contributions that satellite observations could make to the WMS and has adopted a recommendation that plans for the space-research program for this period include a satellite instrumented for magnetic-field measurements.

In the words of E. H. Vestine, Chairman of both the IAGA committee and the GRB Panel on the WMS, "The World Magnetic Survey is not a routine repeat of past survey activities. With the techniques available now, and with the spirit of international cooperation stemming from the IGY, it will be a first-class scientific experiment and will shed much light on understanding the geomagnetic field and its complex interrelationships with electrical phenomena in the upper atmosphere and with the solar-terrestrial environment."

International Activities in Space Science

Fourth Meeting of COSPAR and Second International Space Science Symposium

Since the beginning of the "Space Age," less than four years ago, programs for conducting scientific experiments in space have grown rapidly. While this growth has occurred mainly in the satellite and space-probe programs of the United States and the USSR, numerous other countries are conducting experiments with rockets, receiving telemetry, and engaging in ground-based experiments relevant to those conducted in space. This expansion is notably reflected in the increasing membership of the Committee on Space Research (COSPAR) of the International Council of Scientific Unions (ICSU) and in the activities of its adherents.

The Fourth Meeting of COSPAR was held in Florence, Italy, April 7–18, 1961. The meeting, which included working sessions of the COSPAR organization as well as the Second International Space Science Symposium, was organized jointly by COSPAR and the National Research Council of Italy. Professor H. C. van de Hulst of The Netherlands, President of COSPAR, presided.

COSPAR working sessions were attended by 50 scientists representing the member scientific academies of 18 nations and the 10 affiliated ICSU unions. Meeting in working groups, an executive council, and a plenary assembly, COSPAR adopted recommendations concerning the contributions to be made by rocket and satellite experiments to the International Year of the Quiet Sun (IQSY; see *Bulletin No. 48*) and the World Magnetic Survey (WMS); recommendations were also adopted on a variety of topics concerned with other rocket and satellite experiments, tracking problems, and data interchange.

The number of participants in COSPAR's

Second Space Science Symposium exceeded 300, representing 27 countries and including some 65 from the United States. A total of 117 scientific papers were presented by scientists from 14 countries. The papers will be published shortly by the North-Holland Publishing Company. The scientific sessions covered radio and optical tracking, telemetry and data recovery, geomagnetism, research by use of rockets, reference atmospheres, the geophysical events of July 1959 and November–1960, and recent results from instrumented satellites and spacecraft.

History of COSPAR

COSPAR was established by ICSU in October 1958 as an outgrowth of the rocket and satellite programs of the International Geophysical Year. In its first three meetings, COSPAR developed a charter and organization, and initiated effective programs of international scientific cooperation. Information and results have been exchanged annually on the rocket and satellite programs of scientific institutions of member nations through the rocket and satellite subcenters of the IGY World Data Centers, which are continuing to function under arrangements similar to those employed during the IGY but somewhat more complete.

Under the guidance of COSPAR, an annual series of International Rocket Intervals has been successfully established, and special studies have been initiated—notably, a study of the remarkable geophysical events of July 1959 and November 1960. In addition, reference tables for the properties of the upper atmosphere have been developed and will be published shortly, and the needs of space experiments for radio-frequency allocations have been drawn to the attention of appropriate inter-governmental agencies.

COSPAR's First International Space Science Symposium, held at Nice, France, in January 1960, was attended by about 300 scientists and included 98 papers by participants from 12 countries. It resulted in publication of a valuable volume containing an extensive compilation of scientific results from experiments aboard rockets and satellites.

US Cooperative Programs: COSPAR has provided a climate for international cooperation in other ways. Through COSPAR, an offer was made on behalf of the US National Aeronautics and Space Administration to launch experiments of scientists from other countries. As a result of this offer, the first of three satellites instrumented by the United Kingdom will be launched in 1962. Canadian scientists are preparing an ionospheric-sounder satellite, also to be launched in 1962. With NASA cooperation, Italy has undertaken rocket launchings from Sardinia for sodium-vapor studies of the high atmosphere. Similarly, NASA and Australia are considering a joint program to launch rockets from Woomera, Australia, to map ultraviolet radiation in the southern skies. Similar joint projects are under discussion with other countries.

International Participation in Space Research

Since COSPAR was established there has been a significant increase in the number of nations capable of engaging in space research. Initially, seven member nations launched rockets or satellites as part of the IGY program. In addition to the United States and the Soviet Union, these included Australia, Canada, France, Japan, and the United Kingdom. Membership has now increased to 18 countries, the following 11 having joined COSPAR since 1958: Argentina, Belgium, Czechoslovakia, German Federal Republic, India, Italy, The Netherlands, Norway, Poland, South Africa, and Switzerland. Not all of these 11 countries are actually launching research rockets or satellites, but all participate in space research through tracking and receipt of telemetry from space vehicles, and through ground-based studies and experiments of direct relevance to those conducted in space.

Canada and the United Kingdom, with the cooperation of the United States, may soon be added to the countries that have launched instrumented satellites, and still other countries should follow in the near future. Italy and Israel are new additions to the countries that have launched research rockets, and five or six other countries may be added to this list in the next few years.

The number of scientific communities with access to the technology required to launch scientific instruments into space should continue to increase. Moreover, the opportunities for scientists everywhere on earth to engage in space research are even now more numerous than appears on the surface—even for scientists without access to rocket technology. Investigations under way for many years at earth-based stations have been intensified and expanded as a result of the IGY and the advent of the space age. Much necessary work can be done by increasing balloon research to augment studies at higher altitudes with rockets and satellites.

Small rockets should soon become standard tools for meteorological observations in many parts of the world, and rockets for scientific measurements in other fields will continue to acquire critical information at sub-satellite altitudes for many years. Moreover, data telemetered by many satellites and space probes can be acquired either directly or indirectly by scientists everywhere. Once acquired, these data can be reduced, analyzed, and interpreted by these scientists just as if the experiment aboard the satellite were their own.

Finally, creative ideas for new satellite experiments, conceived and developed by scientists anywhere, have good prospects of realization in the space program of the United States through arrangements similar to those with the United Kingdom and Canada.

The growth in the number of nations engaging in space research in itself corresponds with one of the main objectives of COSPAR's charter. At the same time, this growth increases the opportunities for synoptic, or world-wide, observations and experiments that represent the primary function that COSPAR has inherited from the IGY.

Accomplishments of Fourth Meeting of COSPAR

At the Florence meeting, COSPAR took the first step in organizing a post-IGY cooperative scientific program with world-wide objectives. COSPAR's efforts will be directed toward developing specific contributions by experiments aboard rockets and satellites to important international scientific programs initiated and sponsored by other organizations in the ICSU complex. Two such programs—the IQSY and the WMS—have been organized by the ICSU International Committee on Geophysics (CIG).

The IQSY will undertake, based on knowledge obtained during the IGY period of maximum solar activity, measurements and observations of solar-terrestrial relationships during the coming period of minimum solar activity, in 1964 and 1965. A comparison of the measurements taken during the IGY and the IQSY should prove of immeasurable value to science.

The WMS will attempt to add to the world-wide network of ground-based magnetic observations, for the purpose of developing a new map of the earth's magnetic field, rocket-and-satellite measurements of the magnetic field in space. The WMS will be conducted on an international basis during the same period as the IQSY.

COSPAR's Working Group II, on "Scientific Experiments," adopted 11 general resolutions defining the basic scientific objectives of the IQSY and WMS programs toward which rocket and satellite contributions should be made. Subsequent meetings of experts in specific scientific disciplines will be held to refine these general resolutions through preparation of specific international program recommendations concerning experiments that depend on world-wide coverage, synoptic observations, or both. The first of these meetings will take place at Kyoto, Japan, in September 1961 as an adjunct to the International Conference on Cosmic Rays and Earth Storms, which is being convened under the auspices of the International Union on Pure and Applied Physics.

The Kyoto conference provides an opportunity to assemble scientists in the fields of cosmic rays, energetic solar particles, and geomagnetism from a large number of countries in order to define the specific projects and detailed modes of cooperation required to provide for the fullest elaboration of both the IQSY and the WMS. For example, the possibility exists of using a coordinated pair of satellites for the WMS. These satellites would differ in altitude and orbital characteristics, but would make correlative measurements of the earth's magnetic field.

Other current activities of COSPAR working groups include development of a comprehensive world list of tracking stations for the use of satellite experimenters, further refinement of the world-wide system for rapid communication of satellite and space probe information, and improvements in the arrangements for exchange of scientific results of rocket, satellite, and space-probe research.

Plans for Future Meetings

Further refinement of several aspects of the COSPAR program will be carried out in a series of international meetings and symposia on special space problems; these meetings are being arranged under the auspices of COSPAR for the coming year, in many cases in cooperation with other organizations within the ICSU family. An informal meeting on basic biological problems of space exploration, including exobiology and avoiding contamination of the Moon and planets by vehicles landing on their surfaces, was planned in conjunction with the meeting of the International Union of Biochemistry, in Moscow, August 1961. Also, a special meeting on tracking-accuracy requirements for space research in the Southern Hemisphere was convened as an adjunct to the meetings of the International Astronomical Union, in Berkeley, August 1961.

The National Academy of Sciences and its Space Science Board will act as host at the next General Assembly of COSPAR, to be held in Washington, D. C., April 30–May 11, 1962. This meeting will also include the Third International Space Science Symposium, and two symposia on special topics are being organized in cooperation with other international organizations.

A symposium on the Geodetic Uses of Satellites, planned by the International Association of Geodesy and COSPAR, will probably take place in Washington the week prior to the COSPAR meeting. The second symposium on the Meteorological Uses of Rockets and Satellites will also be convened in Washington, jointly by COSPAR, the World Meteorological Organization, and the International Union of Geodesy and Geophysics, in conjunction with the 1962 COSPAR meeting.

Conclusion

COSPAR is facilitating the expansion of the world's space research by encouraging and assisting new scientific groups to undertake the scientific tasks of space research and by harmonizing the programs based on these separate efforts. COSPAR also provides a suitable environment for discussion and exchange of ideas by space scientists, for indicating technical needs, and for establishing internationally endorsed scientific objectives. Cooperation between groups of scientists working in different countries is thus facilitated because the efforts of each group constitute contributions to scientific programs discussed and developed on an international basis.

Full realization of the scientific possibilities opened up by access to space calls for extraordinary efforts. Some of these efforts will be beyond the resources of any one nation, and the success of many of them, because of their global or cosmic scope, will depend upon the cooperation of a number of nations. The success of all of them would be greatly enhanced if carried out cooperatively.

Tiros III Weather Observation Satellite

Since its successful launch on July 12, 1961, Tiros III (1961 Rho), the third in the Tiros series of television and infrared observation satellites, has transmitted back to earth thousands of cloud-cover photographs, including many high-quality pictures of hurricanes and other large tropical storms. (See Figures 9, 10, and 11.) As the projected experimental lifetime of Tiros III corresponds largely to the current hurricane season, the satellite is thus fulfilling the hopes of meteorologists that it would provide valuable insights concerning the origin, development, and movement patterns of these great storms. Tiros III is also providing weather forecasters with immediately usable information on the location and growth of such storms, as well as on other weather conditions, in oceanic areas for which little or no weather data are otherwise available.

Launched by a 92-foot, 112,000-pound Delta vehicle at 6:25 am EDT, July 12, from Cape Canaveral, Florida, Tiros III entered an almost circular orbit at an average altitude of approximately 485 statute miles. About a month after launch, the satellite's orbital elements were as follows: perigee, 457.4 statute miles; apogee, 509.4 statute miles; inclination, 47.9°; and period 100.4 minutes.

Payload Details and Instrumentation

Tiros III closely resembles its predecessors, Tiros I and Tiros II (described, respectively, in *Bulletin Nos. 35 and 43*), in shape, weight, and dimensions. The 285-pound cylindrical satellite is 42 inches in

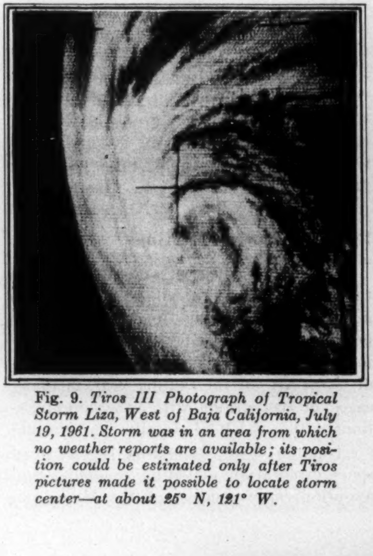

Fig. 9. *Tiros III Photograph of Tropical Storm Liza, West of Baja California, July 19, 1961. Storm was in an area from which no weather reports are available; its position could be estimated only after Tiros pictures made it possible to locate storm center—at about 25° N, 121° W.*

diameter and 19 inches high. Its outer surface is covered with 9260 solar cells to provide electrical energy for the 63 nickel-cadmium storage batteries that power its electronic instrumentation.

Unlike Tiros I and II, each of which carried one wide-angle and one narrow-angle vidicon television camera to provide both low- and high-resolution photographs, Tiros III was equipped with two wide-angle cameras. Experience with the first two Tiros satellites showed that wide-angle pictures were of greater value for weather interpretation. The narrow-angle pictures were found to be useful essentially for research, and a sufficient number of them has already been obtained for this purpose from Tiros I and II. Moreover, Tiros II was still transmitting narrow-angle photographs at the time Tiros III was launched.

One of Tiros III's television cameras failed on July 24, following the satellite's 170th orbit and after taking 2020 high-quality cloud-cover photographs. The other camera was then put into full-time use. The possibility of failure of a camera was one of the reasons for using two identical cameras.

As did the first two Tiros', Tiros III contains magnetic tape recorders that can store up to 32 pictures per orbit for transmission to the earth when the satellite comes within the 1500-mile command range of a ground station. The satellite also carries improved remote-control programmers for the electronic equipment and new transistorized circuits in the electronic clocks that trigger the cameras. Other instrumentation in the latest Tiros satellite, including beacon transmitters, attitude sensors, horizon scanners, telemetry circuits, and a magnetic orientation control system, is identical to that used in Tiros II (see *Bulletin No. 43*).

Tiros III also carries one scanning and one non-scanning radiation experiment that are essentially the same as those carried in Tiros II, plus one additional non-scanning experiment. The scanning experiment, consisting of five sensors to map radiation in various spectral ranges, is designed to provide information on reflected solar radiation, on long-wave radiation emitted from the earth and the atmosphere, on temperatures of the earth's surface or of cloud tops, and on the upper margin of water vapor in the atmosphere.

The first non-scanning experiment is intended to provide gross heat-budget information for the portions of the earth's surface and atmosphere viewed by the television cameras. The new non-scanning experiment is similar to one used successfully in the Explorer VII satellite (see *Bulletin No. 29*) and also measures the gross heat budget; however, the data will be nearly continuous as the sensors view the earth almost all of the time.

Data from the radiation experiments are recorded continuously on magnetic tape through one orbit and are played back on command from one of the ground stations. If not played back during an orbit, the tape is automatically erased as it accumulates new data from the next orbit.

Ground-Command Stations

The two primary NASA stations for command and data read-out in the Tiros III experiment are at Wallops Island, Virginia, and the Pacific Missile Range, California. Stations located at the Atlantic Missile Range, Florida, and at RCA's facility in Princeton, New Jersey, serve as back-up.

International Cooperation

Immediately after successful orbit of Tiros III was verified, notification was sent to COSPAR, in The Hague, along with initial orbital data and a description of the satellite and its instrumentation. In addition, NASA and the US Weather Bureau have invited other countries to participate in the experiment in order to provide them with the opportunity to correlate their own

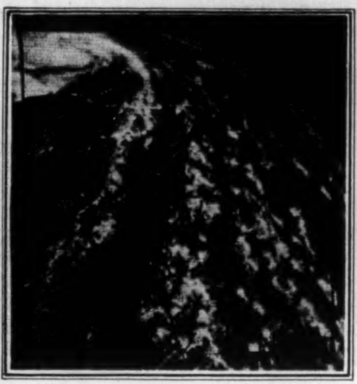

Fig. 10. *Tiros III Photograph of Hurricane Anna, July 20, 1961, at 13° N, 65.5° W. Cloud-covered Leeward and Windward Islands, in the West Indies, appear as line of bright spots transverse to main spiral cloud band.*

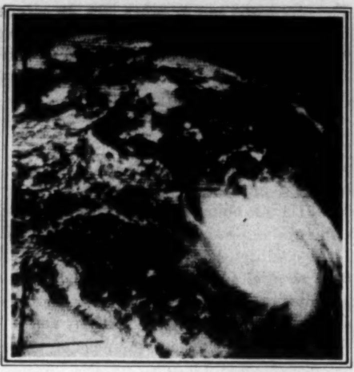

Fig. 11. *Hurricane Anna, July 21, 1961, about 25 Hours After Picture Shown in Figure 10 was Obtained. Hurricane's center had moved to about 14° N, 72° W, some 450 miles to the west. Coast of Colombia near Barranquilla is near center of photograph; Lake Maracaibo, Venezuela, is prominent dark area below center.*

ground-based observations with Tiros III cloud-cover photographs.

International Meteorological Satellite Workshop: The US Weather Bureau and National Aeronautics and Space Administration will hold an International Meteorological Satellite Workshop in Washington, D. C., November 13–22, 1961. More than 100 nations of the world have been invited to send one or two meteorologists each.

Through a series of lectures and laboratory-type meetings in which they will use Tiros photographs to prepare weather analyses, the participants will gain practical experience in the use of the satellite meteorological data distributed by the United States through international meteorological channels. Short lectures will also cover engineering aspects of the Tiros satellite system, the data acquisition system, significant results thus far, and program plans for future meteorological satellite systems. If a weather satellite is functioning during the period of the workshop, participants will be shown the principal ground elements of the system in actual operation.

While the Tiros program has demonstrated the great potential of weather satellites as important sources of forecast information for weather services, the introduction of this new type of data into daily weather analyses has presented problems that are as yet only partly solved. Discussions among meteorologists of the world may provide some answers.

Preliminary Results

Tiros III has transmitted photographs of a large number of tropical storms around the globe in a 6600-mile-wide band between approximately 48° N and 48° S during the past summer. Among these were some in oceanic areas where regular weather observation facilities are lacking. Figures 9, 10, and 11 are Tiros III pictures of three of these storms taken during the satellite's first few weeks in orbit.

Among the storms for which no previous

information was received from regular sources were two, still in the infant stage, photographed about 500 miles south and southeast of Hawaii on August 17. In addition, cloud pictures made available to Japan in the early summer proved to be of very considerable aid in weather prediction, and it was hoped that Tiros III's passes near Japan from about August 18 to September 25, a period during which typhoon activity was expected to be high, would also provide vital assistance to forecasters.

Energetic Cosmic-Ray Air Shower

An extremely large cosmic-ray air shower, triggered by a primary cosmic-ray particle that probably originated outside our galaxy, has been observed at the Volcano Ranch cosmic-ray station of the Massachusetts Institute of Technology. The station, at an elevation of 5800 feet near Albuquerque, New Mexico, employed an array of scintillation counters designed to detect and measure such showers. The event is described in a report by John Linsley, Livio Scarsi, and Bruno Rossi, in *Physical Review Letters*, May 1, 1961.

Primary cosmic rays entering the earth's atmosphere collide with nuclei of atmospheric atoms. These collisions produce secondary cosmic-ray particles, which, in turn, strike still other air particles, producing tertiaries, and so forth. Thus, the entry of high-velocity cosmic rays into the earth's atmosphere may result in showers at the earth's surface consisting of hundreds of millions, or billions, of particles.

The core of the shower described struck the earth's surface several hundred meters south of the boundary of the array of 19 detectors, which occupied an area of approximately two km^2. On the basis of the particle densities observed at the various detectors, it was calculated that the total number of particles in the shower was at least 5.5 billion, and may have been 4 to 8 times that many.

A cosmic-ray air shower of this size could be precipitated only by a primary particle having an energy of 10^{19} electron volts or greater. In a magnetic field of 3×10^{-6} gauss, the commonly estimated intensity of the galactic magnetic field, a proton of this energy would have a radius of curvature of about 10^4 light years. However, the radius of our galaxy is only about 5 times this value while its thickness is approximately 5 or 10 times smaller. Thus, it appears certain that the primary particle causing this shower must have acquired its energy outside our galaxy. Cosmic-ray primaries originating within our galaxy could have energies up to about 10^{19} ev, but not greater.

Analysis of the distributions of arrival times and particle densities at the various detectors indicates that the extreme front of the shower was well-defined, and that, while many particles were delayed by as much as 1 or 2 microseconds, few of them were delayed by more than twice the mean delay time. It appears that these general features of distribution also characterize smaller showers. It also appears that the radius of curvature of the front of this shower was about 10 to 12 kilometers, i.e., an appreciable fraction of the air-shower particles began to diverge strongly from the shower axis in this height range. The results further suggest that for shower particles arriving at distances greater than 1500 meters from the shower axis, at an elevation of 5800 feet, this divergence from the axis occurs at heights greater than 7 km above the ground.

Since the Volcano Ranch Station went into operation, in September 1959, only two such high-energy cosmic ray events, apparently involving extra-galactic particles, have been detected.

West Ford Review

(A Review of Space Science Board Activities and the United States Government Policy Position)

A report in the August 1961 IGY Bulletin *described the design and purpose of the Project West Ford communications experiment and discussed its possible relationships to other branches of science. The following is a summary report distributed by the National Academy of Science's Space Science Board to the scientific public and the press concerning the Board's activities and findings regarding Project West Ford and including the full text of the policy position announced by the United States Government on August 11, 1961, concerning the experiment.*

A Summary Report on Project West Ford

Project West Ford is a proposed program of the United States Government to investigate experimentally a new system of long range communications. Because the experiment proposes to place a narrow belt of minute microwave reflectors in a high altitude orbit, astronomers have been interested in the experiment, many expressing concern that interference to basic astronomical measurements might ensue.

The Space Science Board of the National Academy of Sciences, which has closely followed development of this project since its inception, considers it useful to recapitulate the plans for this experiment and to place in proper perspective its views regarding the interests of basic science. For this purpose there follow:

I. A résumé of Space Science Board activities and findings regarding Project West Ford
II. A statement of the policy position of the United States Government regarding the project
III. The Board's views on the question of possible effects on astronomical research.

I.

In the fall of 1959 the Space Science Board was informed of the proposal by the Massachusetts Institute of Technology Lincoln Laboratory to erect a belt of thin microwave dipoles in a polar orbit about the Earth at an altitude of a few thousand kilometers to obtain experimental verification of such a system for reliable long range radio communications. This experiment involves the establishment of a belt consisting of some 35 kilograms of dipoles, resonant at about 8000 megacycles and therefore serving to reflect radio waves at this frequency.

Each dipole is 1.77 centimeters long with a diameter of 0.00286 centimeters. 3.5×10^8 dipoles are involved, distributed uniformly along the orbit and subsequently dispersing until, at 60 days after launch, a belt 8 kilometers wide by 40 kilometers thick is formed. At this time the density will be about 21 dipoles per km^3. The orbital altitude for the experiment has been chosen to ensure that solar radiation pressure effects will act to produce an ever increasing eccentricity in the orbit, thus bringing perigee into the atmosphere within a few years with consequent belt destruction.

Extensive theoretical and laboratory studies of the properties of orbiting dipole belts have been carried out by Lincoln Laboratory. In addition, at the request of the Director of Lincoln Laboratory, the Space Science Board undertook to examine the effects of the proposed experiment to ascertain whether the project would have any noticeable effects on activity in any field of research.

The Board, on December 24, 1959, appointed an ad hoc committee of scientists under the chairmanship of Dr. O. G. Villard, Jr. (Stanford University) to examine the consequences of the proposed experiment. Astronomers on this committee included G. M. Clemence (U. S. Naval Observatory), C. H. Mayer (Naval Research Laboratory), and F. L. Whipple (Smithsonian Astrophysical Observatory). The committee held several meetings during the first half of 1960 and invoked the assistance of some 20 additional scientists including optical and radio astronomers and other specialists.

Acting upon the findings of this committee, the Space Science Board in June 1960 reached a number of conclusions and adopted several recommendations: (i) This exploratory test would not have an adverse effect on any branch of science. (ii) There is justifiable concern for the interference which an operational system might entail for optical and radio astronomical observations: any planning for such a system must protect the interests of astronomical research and of science in general. (iii) Full information on the scientific and operational aspects of the initial experiment should be published as soon as possible. (iv) In view of the possible interference to radio astronomy, which might result not only from extensive dipole belts but also from active and even passive communication satellites, frequency bands for radio astronomy should be provided on the basis of world-wide agreements.

The Board also decided that continued study of the subject was worthwhile, and in this the Lincoln Laboratory concurred. Accordingly, the Board established a special committee on July 29, 1960. The present composition of this committee is as follows: John Findlay (National Radio Astronomy Observatory) (Chairman), F. T. Haddock (University of Michigan), William Liller (Harvard University), A. E. Lilley (Harvard University), W. A. Hiltner (Yerkes Observatory), and Allan Sandage (Mount Wilson and Palomar Observatories). Leo Goldberg (Harvard University), chairman of the Board's astronomy committee, meets with the group. The committee was asked by the Board to examine carefully all calculations of the effects of the West Ford experiment on astronomy, to recommend additional necessary research or study, and to report its scientific findings to the Board. The committee has maintained continuous liaison with the project throughout the past year and has formally convened with West Ford project directors of Lincoln Laboratory on three occasions. At each of these sessions the committee has received a thorough review of the project status and full information on all parameters of the experiment.

The Space Science Board has felt that a discussion of the proposed experiment should not be limited to committee consideration. but should be brought out for critical analysis by the scientific community as a whole. Accordingly, as a result of the foregoing recommendation (iii) of the Space Science

Board and following almost immediately the initial discussions of its committee with Lincoln Laboratory scientists (29 August 1960), the Laboratory concurred with the request for presentation of their work on orbiting dipole belt properties to the international scientific community. Dr. W. E. Morrow, Lincoln Laboratory Project West Ford Director, presented a paper on the topic before the general assembly of the International Scientific Radio Union (URSI) in London in September 1960.

The Board has also recommended that the theoretical and technical aspects of the West Ford project should be published in the astronomical literature so that astronomers throughout the world could examine for themselves the calculations on which the project is based. For this purpose, four articles were published in the *Astronomical Journal,* Vol. 66, No. 3, pp. 105–118, April 1961. Some 1400 copies of these papers have been distributed by the Board to the scientific community, over 1100 of them to members of the International Astronomical Union, including 800 astronomers abroad.

During the course of its considerations the Committee also established the desirability of securing the widest possible participation of observational astronomers to study the characteristics of the Project West Ford belt to determine its performance under actual conditions. In March, 1961, the committee distributed a circular letter to a large number of optical astronomers throughout the world (i) providing a technical description of the experiment, (ii) containing recommendations for an observational program which might be undertaken, and (iii) inviting the cooperation of individual astronomers in obtaining observations and measurements.

II.

The Space Science Board's recommendations on Project West Ford have been made available to the government as they were developed. In response to these recommendations, made by the Board on behalf of the scientific community, the government has issued appropriate policies. These, as transmitted by the Special Assistant to the President for Science and Technology to the Chairman of the Space Science Board, follow in full:

THE WHITE HOUSE
Washington

August 11, 1961

Dear Dr. Berkner:

I would like to acknowledge the recommendations and assistance of the Academy's Space Science Board in its studies of the proposed West Ford experiment. In particular, I should like to note with appreciation the consideration given to this topic, at my request, during the last few months as to the effects of the experiment and possible other experiments from the standpoint of science as a whole.

As a result of these technical studies, a statement of policy was prepared by the National Aeronautics and Space Council—a body whose Chairman is the Vice-President of the United States and whose members include the Secretary of State, the Secretary of Defense, the Administrator of the National Aeronautics and Space Administration, and the Chairman of the Atomic Energy Commission. This statement, which I believe expresses the interest of all parts of the Government in continued development of basic science, has been approved by the President.

I would be pleased if you would disseminate the statement, a copy of which is enclosed, to members of the scientific community.

Sincerely yours,
Jerome B. Wiesner

Project West Ford: U. S. Policy

"Project West Ford is a communications experiment designed to place about 75 pounds of hair-like filaments (dipoles) into a short-lived belt around the earth. This project has been planned in such a way that no harmful effects can be expected. It is being performed for the United States Government by the Lincoln Laboratory of the Massachusetts Institute of Technology and is a single experiment for the purpose of:

"a. Investigating the technical feasibility of utilizing orbiting dipoles as passive reflectors for relaying communications; and "b. Providing an opportunity for an objective assessment of the possible effects of the dipole technique on space activities or on any branch of science.

"The United States Government, in conducting the West Ford Project, will be guided as follows:

"1. No further launches of orbiting dipoles will be planned until after the results of the West Ford experiment have been analyzed and evaluated. The findings and conclusions of foreign and domestic scientists (including the liaison committee of astronomers established by the Space Science Board of the National Academy of Sciences) should be carefully considered in such analysis and evaluation.

"2. Any decision to place additional quantities of dipoles in orbit, subsequent to the West Ford experiment, will be contingent upon the results of the analysis and evaluation and the development of necessary safeguards against harmful interference with space activities or with any branch of science.

"3. Optical and radio-astronomers throughout the world should be invited to cooperate in the West Ford experiment to ascertain the effects of the experimental belt in both the optical and radio parts of the spectrum. To assist in such cooperation, they should be given appropriate information on a timely basis. Scientific data derived from the experiment should be made available to the public as promptly as feasible after the launching."

III.

In the light of its studies and of the above governmental policy, the Space Science Board concludes:

(1) The Project West Ford experiment will constitute no interference to optical or radio astronomy. As a matter of fact, the belt will be barely detectable, even by astronomers with advance information and upon the taking of special efforts for detection.

It is true that a belt or belts could be erected which could cause interference to astronomical observations; however, the United States Government policy provides (Section II, above) that no further launches of orbiting dipoles will be planned (i) until the West Ford results have been analyzed and evaluated and, further, (ii) will be contingent on the development of necessary safeguards.

(2) The Board will continue its studies of this area of experimentation on behalf of the scientific community. In these studies it will depend on objective and quantitative assessments that constitute the foundation for scientific discussions, recommendations and decisions. These assessments can only be achieved through a carefully controlled, harmless test, and Project West Ford provides a clear opportunity for scientists of all nations to cooperate in making observations to form the basis for an objective understanding of the behavior of an orbiting dipole belt, both in terms of its astronomical properties and of its communication capabilities.

(3) The Board will continue to keep the scientific community everywhere informed and it invites the cooperation and assistance of scientists everywhere who have interest and specialized knowledge in this area. The Board acknowledges with gratitude the assistance of many scientists—both at home and abroad—who have already contributed to its studies.

International Astronomical Union Resolutions

The Eleventh General Assembly of the International Astronomical Union, held in Berkeley, California, August 15–24, 1961, adopted two resolutions concerning the launching of space experiments that might affect astronomical research. The full text of these resolutions is as follows:

Resolution No. 1—Viewing with great concern the grave danger that some future space projects might seriously interfere with astronomical observations in the optical as well as in the radio domain,

and *believing* that a degree of contamination of space which at the present time would be hardly detectable, might, if long-lived, well be disastrous to future observations with improved techniques,

and *maintaining* that no group has the right to change the Earth's environment in any significant way without full international study and agreement;

the International Astronomical Union *gives* clear warning of the grave moral and material consequences which could stem from a disregard of the future of astronomical progress,

and *appeals* to all Governments concerned with launching space experiments which could possibly affect astronomical research to consult with the International Astronomical Union before undertaking such experiments and to refrain from launching until it is established beyond doubt that no damage will be done to astronomical research.

Resolution No. 2—The International Astronomical Union expresses its appreciation that the plans for Project West Ford have been publicly announced well ahead of proposed launching and of the United States Government's official policy* that further launchings will be guided by the principle that such projects shall not be undertaken unless sufficient safeguards have been obtained against harmful interference with astronomical observations.

Nevertheless the International Astronomical Union views with the utmost concern the possibility that the band of dipoles proposed in Project West Ford might be long-lived, and it is completely opposed to the experiment until the question of permanence is clearly settled in published scientific papers with adequate time being allowed for their study. The International Astronomical Union is opposed to any experiment which might hamper future developments in astronomy.

If a short lifetime for the dipoles and the harmless nature of the experiment can be assured, and if Project West Ford is carried out, the International Astronomical Union regards it as essential that the fullest observations of, and experiments on, the properties and behavior of the band of dipoles be carried out by all possible means. The observations and experiments should be performed and analyzed according to the highest scientific standards and with the best equipment available, bearing in mind that signals which are barely detectable today will probably cause serious interference with future scientific research because of the development of more sensitive equipment.

The observations and experiments to be made on West Ford are likely to be difficult to perform and will, in many ways, be similar to those carried out by the authorities responsible for operating West Ford. Moreover, much specific information such as precise and up-to-date ephemerides will be required. The International Astronomical Union will attempt to arrange for rapid and full cooperation among astronomers making observations and calculations, and to provide for world-wide dissemination of their results conforming to accepted standards of scientific research.

The International Astronomical Union welcomes the position* taken by the Government of the United States that any decision on later experiments of the West Ford type will be taken in the light of the results obtained from the presently proposed experiment. To enable the International Astronomical Union to obtain the necessary data, it requests the Government of the United States to grant full privileges to a group of astronomers, acceptable both to the Government and to the Union, to co-operate with West Ford authorities in performing quantitative experiments to determine the properties of the proposed belt of dipoles, its changes with time and location, and its impact upon present and future astronomical research.

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* Letter of August 11, 1961, from Dr. J. B. Wiesner to Dr. L. V. Berkner.

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